Harvard Graduate School of Design
Laboratory for Design Technologies (LDT)
Responsive Environments & Artifacts Lab (REAL)

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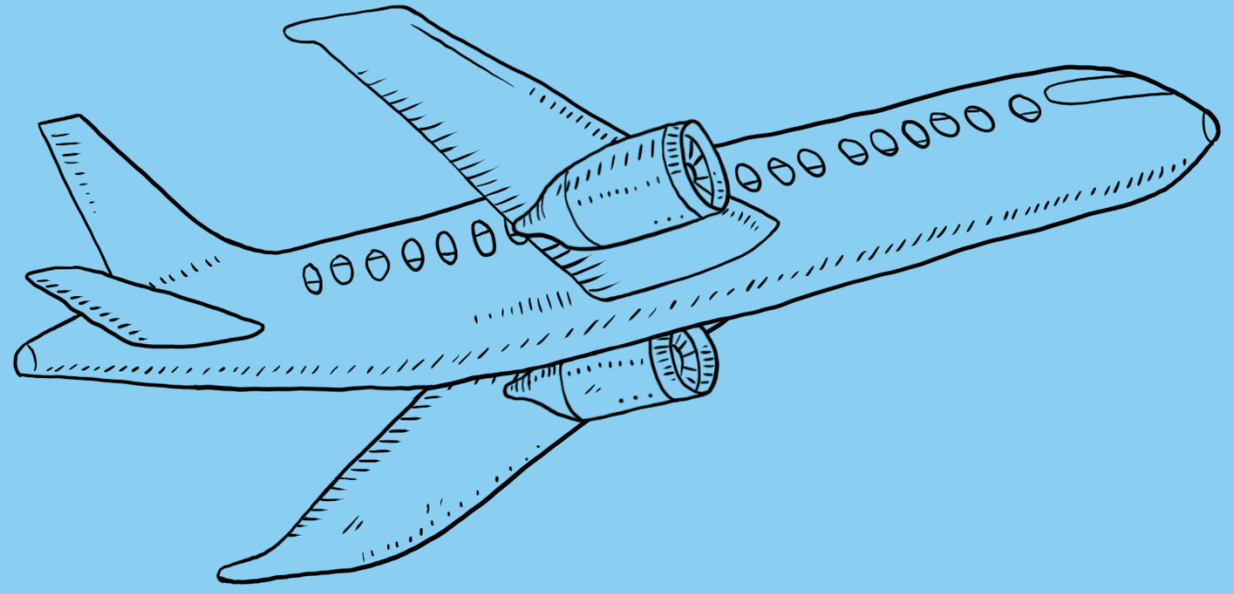
ON FLYING

THE TOOLKIT OF TACTICS THAT GUIDE PASSENGER PERCEPTION



HARVARD GRADUATE SCHOOL OF DESIGN
RESPONSIVE ENVIRONMENTS & ARTIFACTS LAB (REAL)

Harvard Graduate School of Design
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Researchers: Allen Sayegh, Humbi Song, Zach Seibold, Isa He
Illustrator: Isa He
Graphic Designer: Dann Spann

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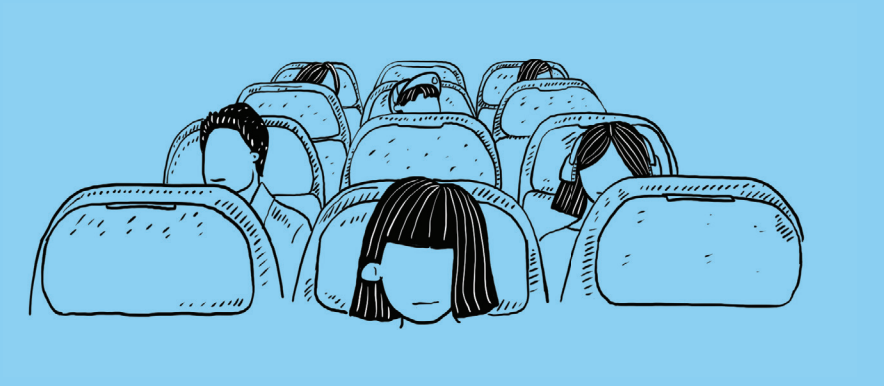
INTRODUCTION

“As air travelers we are dependent. In flight, an experience that sets off all sorts of limbic alarms, we relinquish control.

We’re told when to buckle up, when to get up, when to ask for liquids, even when to pee. We are scolded: Unless we sit down, the plane will not leave.

We largely cease to be individuals.”

- Mark Gerchick



There was once a time before flying became ordinary.

This yearning for flight is a familiar, universal human longing - but one could be forgiven for forgetting that. Flying became mundane at some point, both historically and personally; historically, as airplane travel became much more accessible as a mode of transportation, and personally, as we outgrow our individual childhood dreams of flying. Our cultural perception of air travel is far more ambivalent today, tinged with unease and anxiety. No longer do we begin with "Consider Icarus," but rather we ask "is the air travel experience inherently unpleasant?" That is not to say that our longing for airborne freedom is lost. However, people have come to recognize that the air travel experience as it exists today cannot help us satisfy our once dearly-held dreams of flying.

Why is this the case? The principal reason for this is that there is a fundamental tension between the needs of the airport and airline (the institutional desires) and the desires of the passengers (individual desires). The airport and the airplane need to facilitate the flow of enormous masses of people efficiently and expediently, while also being accountable to the state as a site of national or regional border control. In order to do so, the airport must track and surveil individuals, direct passengers' bodily movements, and limit their personal autonomy for the sake of allowing the maximum number of people to get to their destination safely. This comes in direct conflict with people's innate desire for agency and autonomy - the ability to control for oneself what to do and where to go. Flying no longer fulfils its promises of airborne freedom, as one's individual freedom is severely restricted in the realities of today's air travel.

This tension plays out within the individual as well; there is an internal conflict between the desire for expediency and the desire to hold onto one's agency. The individual wants to get through the air travel experience as quickly as possible, partially because of the cultural perception that it is a dehumanizing and unpleasant experience. Knowing that voluntarily limiting one's autonomy will facilitate a speedier experience, one does so willingly. Some even go so far to chastise others for creating interruptions in the orderly process, judging fellow passengers for forgetting to take off their shoes and holding up the line.

In effect, the airport functions as if passengers have signed a **social contract**. In exchange for security, efficiency, and access to flight technologies, passengers willingly limit one's own autonomy, subject themselves to

"Consider Icarus, pasting those sticky wings on,
testing that strange little tug at his shoulder blade,
and think of that first flawless moment over the lawn... Admire his wings!"

- Anne Sexton

sorting and surveillance, and even enforce these policies around them by creating new unspoken rules and etiquette.

However, we have yet to find the right balance; neither the passengers nor the airports and airlines emerge from the experience satisfied. One problem is the way that objects, spaces, and systems are designed today in the air travel industry. Because design has been driven so unilaterally by safety and logistics, it has left behind many considerations for the human experience.

Because of this mismatch, passenger can feel as if they are at the mercy of nature, airport security, or the cabin crew. They are directed where to go, how to move, and even when to go to the bathroom on the airplane. The architecture is designed to both explicitly and subconsciously direct people along the subdivided spaces of the terminal. In response, people develop various tactics to give themselves the illusion of control.

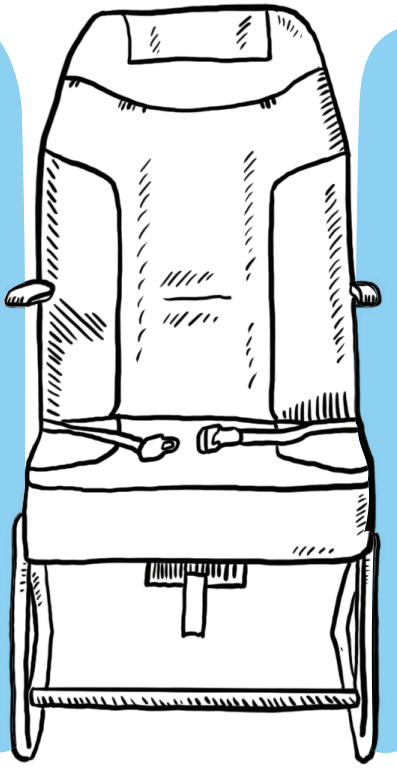
In this book, we catalog each artifact that passengers interact with during air travel to understand

1) what are the driving factors of their design,
2) how do passengers experience it, and
3) what if designers reframed and rethought the experience?

These are interspersed with explorations of key concepts, themes, and phenomena that dominate the passenger experience. Altogether, it is an analysis of the toolkit of tactics deployed by airports and airlines to guide passengers along, in order to facilitate a rethinking of how to design objects, spaces, and systems by putting the human experience at the forefront.

ARTIFACTS

Airplane Seat



“The seat is easily the most important ingredient in the airplane interior. Make a man comfortable, and everything looks rosy to him. He can relax, his food tastes better, the trip will seem hours shorter.”

DESIGN DECISIONS

The airplane seat is crucial to passenger comfort, as a **zone of area which passengers' movements are usually limited to during a flight**.

The choice of materials of an airplane seat is dictated primarily by requirements of weight, durability, and safety in the case of a crash. To reduce fuel use, airlines seek to minimize the **weight** of any object on board as much as possible, and the choice of seat textiles are determined primarily by their **durability**, to withstand the heavy usage throughout their life cycle of 6-10 years before an interior overhaul. In terms of **safety**, all parts of the seat must comply with aircraft fire regulations,[1] and no part should come apart in a manner that would pose a safety hazard to the passenger, should there be a crash.

The economic feasibility of air travel is dependent upon spatial efficiency. These pressures to maximize space has led to "**cabin densification**" across airlines, felt most strongly in the economy class. Seats have become slimmer and legroom has diminished. While 34 to 35 inches of distance between seats was once common for economy class, most aircrafts currently allot 30 to 31 inches of distance, with some carriers providing only 28 inches.[2] Aircraft manufacturers have endeavored to be prepared for numerous spatial strategies for maximizing efficiency, filing patents that anticipate a wide range of possible design directions (See Figures 1 and 2).

This trend is counterbalanced, however, by regulations that mandate a certain ratio of flight attendants to seats; an increase in the flight crew also increases overhead and labor costs for the airlines.[2] Additionally, the COVID-19 pandemic has introduced new physical distancing requirements, and have made passengers reluctant to even consider traveling by air. As personal space becomes more important due to COVID-19, the trend toward cabin densification may have halted.

"Never before has air travel seemed so democratized, affordable to so many, yet so stratified, turning economy into steerage with pretzels"[3].

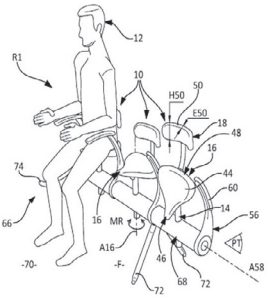


Figure 1. Patent for bicycle type seats to "reduce bulk"

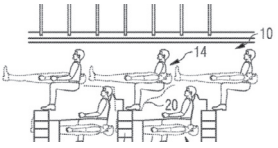


Figure 2. Patent for maximizing efficiency while also maintaining the ability to recline into a bed.

EFFECTS ON PASSENGERS

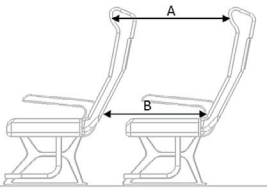


Figure 3. Two specified variables relating to seat space: Sitting pitch (A), Legroom (B)

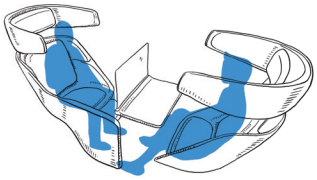
Passengers and human factors researchers primarily focus on **legroom** as one of the most important factors influencing comfort in the economy class.[4,5] A variety of studies have also sought to identify the optimal **seating pitch**, which is the distance between the same two points on a seat from the seat in front.[4] One study identified the optimal seating pitch as 34 inches to 40 inches, depending on the passengers' bodily proportions. Notably, it also observed that an increase in the distance beyond that did not necessarily correlate with increasing comfort. In fact, "**there is a turning point where larger seat pitches lead to less well-being**",[4] perhaps as a result of passengers feeling overexposed.

The amount of legroom is a useful shortcut for assessing comfort levels, but other factors also contribute significantly to the feeling of comfort in one's seat. The overall well-being of a passenger is influenced by both physiological and psychological factors.[4,5] Passenger surveys have specifically highlighted **proximity to neighbors, perception of hygiene, and crew attention as key psychological factors[6]**. In particular, invasion of personal space is a critical source of discomfort for aircraft passengers. While many of these invasions often take the form of physical encroachments, other sensory factors play major roles, including smells, noise, or eye contact.[7] (See: *Armrest, Comfort, and Space*)

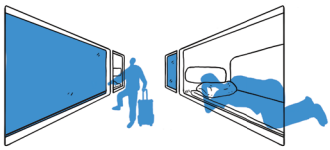
What if airplane seats were integrated with Internet of Things (IoT) systems?
Various companies have been developing sensor systems that keep track of seatbelt usage and reclined seats so that the crew would not have to do time-consuming and intrusive monitoring during take-off and landing. These technologically integrated seats could also monitor other conditions such as hydration or anxiety levels, but will also have to be respectful of privacy concerns.

What if instead of organizing the cabin by class, it was organized by usage types?
These usage types might be family lounging, computer work, gaming, and sleeping. When purchasing tickets today, families often try to reserve a row of seats for themselves; this would be a natural extension of that inclination. Machine learning could be used to help optimize the seating configuration, so that more convivial activities like family lounging and gaming would be adjacent, and quieter activities such as work and sleeping could be paired elsewhere. Airbus's Cabin Vision 2030 video (Figure 4) shows such a proposal, showcasing dedicated spaces for five general passenger personas: a young family, an elderly couple, a gamer, a business worker, and a sleeper.[8]

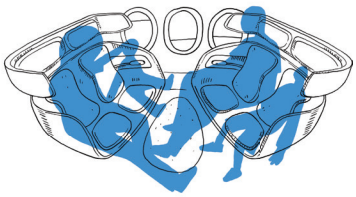
What if airplane seats were staggered, to allow for greater personal space for each seat, and to assist with Covid-19 social distancing practices?
With the advent of Covid-19, a temporary solution to social distancing protocols has been to leave the middle seat empty. The middle seat is already popularly deemed the most uncomfortable and awkward seat on the plane. Several proposals have been made that give greater personal space to the middle seat, and some can easily be adapted to also address Covid-19 (Figures 6, 7). The seats could be staggered sequentially to allow for each window, middle, and aisle seat passenger to have their own armrest and sense of dedicated space.[9] Another solution is a staggered S-shape pattern with the



Persona Type:
Business traveller



Persona Type:
Sleeper



Persona Type:
Young Family

Figure 4: Airbus's Cabin Vision 2030 video shows such a proposal, showcasing dedicated spaces for five broad passenger personas: a young family, an elderly couple, a gamer, a business worker, and a sleeper"

middle seat facing opposite from the window and aisle seats. A curtain could wrap around the seats in an S-shape to provide extra contact protection to each passenger.[10]

What if airplane seats were not fixed in place? What if they could be shifted and reconfigured based on the number of passengers?
Airplane seat layout changes normally take a day to implement, but a different design approach could allow for faster and easier seat reconfiguration according to real-time passenger count for that flight. One such idea is proposed by Airbus's "Smart Cabin Reconfiguration" system, which features foldable seats installed along a floor rail (Figure 5). This system would allow the cabin crew to quickly adapt the number of seats to the number of passengers scheduled to board. If a flight is not full, the empty seats could be folded up to become more compact, and slid along the floor rail toward the back. Then the remaining seats could be spaced further apart, allowing more legroom and comfort for the passengers onboard.[1]

Figure 5: Airbus "Smart Cabin Reconfiguration" system - foldable seats installed along a floor rail

Figure 6.
S-shaped Janus seats with middle seat facing the opposite direction

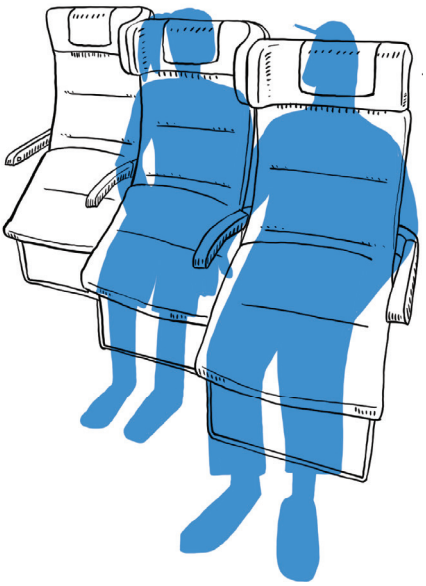
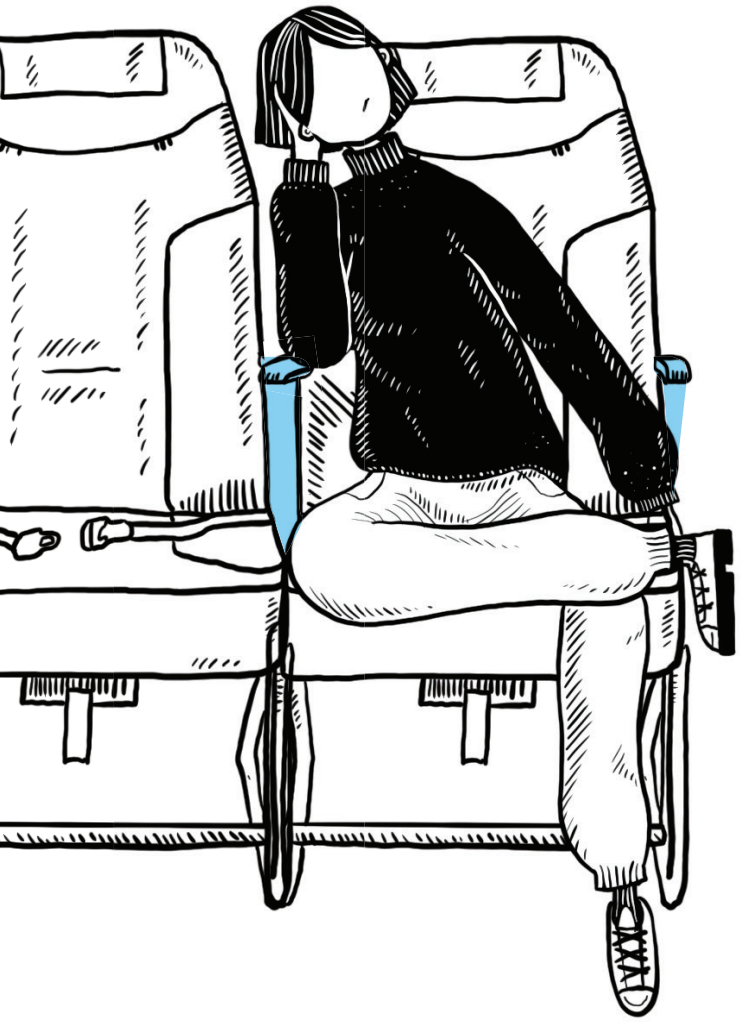


Figure 7: Thompson Suite staggered seats

Armrest

The design of an airplane seat is particularly crucial to passenger comfort, as **a zone of area** to which passengers' movements are often limited.



DESIGN DECISIONS

The armrest is a structure that provides support for the forearm at the side of chairs and sofas, a feature so ubiquitous that it rarely draws much attention. In the airplane context, however, the armrest has gained an outsized symbolic importance in the passenger experience. As airlines move toward more tightly packed seating arrangements, the **armrest has become a flashpoint for the issue of the lack of personal space** on the plane. The seemingly small question of who gets to use which armrest has provoked numerous "**armrest wars**" among adjacent passengers, and intensified resentment among the economy class passengers toward fellow passengers and airline companies.

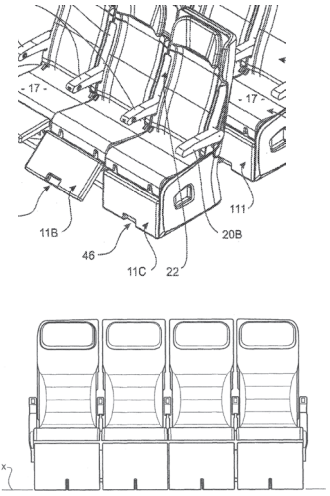


Figure 1. US Patent for Airplane seat US20150203207A1

The current design constraints for armrests primarily relate to issues of safety in the event of crash landing, material wear and tear, and spatial maximization.

1) Safety: The armrest, which can be moved up or down, is required to be down during take off or landing, and a hinge lock keeps the armrest in the down position[1]. This ensures that the armrest does not slam into the passenger in the event of a crash.

2) Material: The material must be highly abrasion resistant, as the armrest is one of the most high-touch surfaces on the plane. Thermoplastic polyurethane is a popular material option for this reason, a type of plastic with abrasion-resistant, UV-resistant, chemical-resistant, and elastic properties[2]

3) Spatial Maximization: The decision to have a single shared armrest between two seats in the economy class is a response to financial pressures to fit more passengers in the aircraft. First class and business class seats rarely have shared armrests, or other such ambiguity about the boundaries of a passenger's personal space.

EFFECTS ON PASSENGERS

Personal space has been defined as "the emotionally tinged zone around the human body that people feel is their space" where individuals feel a sense of ownership and any intrusion of it leads to feelings of discomfort, stress, and avoidance.[3,4] The armrest problem has come to symbolize the issue of the lack of personal space on the plane, as the most visible part of the much larger problem. The **variety of personal space encroachments** that passengers undergo can include bodily noise, undesired conversations, undesired gaze, smells, physical contact, and physical proximity. The outsized emotional reaction to armrest intrusion is likely not just about the armrest, but rather the accumulation of physical discomfort created by all of these intrusions.

"Terms such as 'claustrophobia', 'cramped', 'closed in', 'constricted' and 'fidgety' were associated with physical spatial invasions, including use of the shared armrest and outstretched legs"[4].

This is further compounded by factors unique to air travel, specifically the increased difficulty in removing oneself from uncomfortable situations, and the increase in the amount of time one may need to tolerate personal space invasions. This creates **higher levels of stress about the prospect of direct confrontation**. leading many people to employ non-direct coping strategies from dropping hints, passively reclaiming space, to ignoring the issue and distracting oneself.[4] Even in a non-airplane context, it is unusual for people to confront others directly about space intrusions.[5] This may explain the popularity of semi-humorous lists of passive-aggressive strategies to take during "armrest wars", as people fantasize about how they could have responded in past situations[6]

"Since you can't confront your neighbor any more than you can ignore him, you're left with one option: cunning. If your seat partner is violating your personal space, return the favor...subtly. Drop something on the ground near them, and ask them to pick it up. Either they'll pick it up, removing their arm from the armrest, and you'll be able to swoop in—or they won't, and then you'll know you're seated next to a sociopath, which seems like a good tidbit to file away"[6].

Lastly, the presence of physical and situational **inequality on airplanes have been shown to increase incidents** of outbursts and "air rage".[7] It is possible that the knowledge that the armrest problem is specific to the economy class, and that passengers in the first class and business class have the luxury of larger and more clearly defined personal space, might increase the likelihood of emotional outbursts and negative feelings.

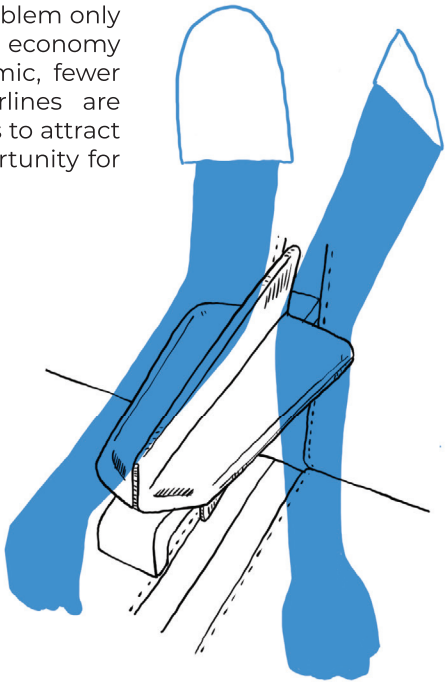
WHAT IF?

1. **What if armrests were shareable without physical contact?**
Numerous designers have attempted to solve the so-called "armrest problem". Soarigami has created a foldable attachment that is placed on the airplane armrest. Soarigami's attachment provides a barrier and two flat surfaces for the person in the middle seat and the person next to the middle seat. The barrier blocks uncomfortable contact with the person next to you while letting you have an armrest.[8] Another proposed solution, from Paperclip Design, is a double-deckered armrest. Adjacent passengers can share the armrest without uncomfortable contact, as the single armrest loops to create two levels.[9]

Figure 2: Paperclip armrest design (above)

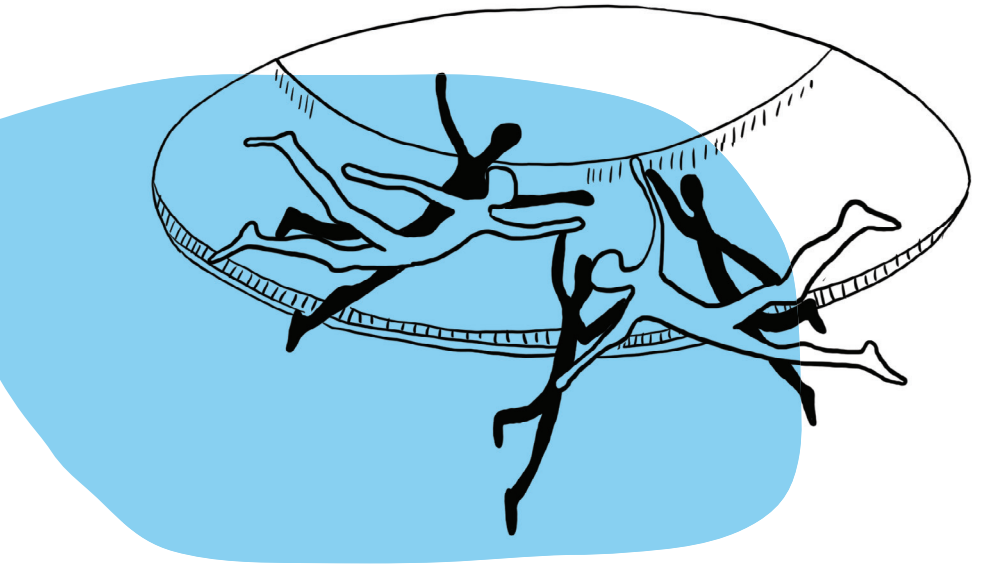
Figure 3: Soarigami armrest design (below)

2. **What if economy class seats offered more space, with a more defined personal space boundaries?**
Business and first class seats have more defined personal space boundaries than economy class seats, and this contributes significantly to their passengers' comfort levels. The middle seat armrest problem only exists because of cabin densification in the economy class. In the wake of the Covid-19 pandemic, fewer people are traveling altogether and airlines are offering more luxuries and ticket flexibilities to attract more passengers. This may be a rare opportunity for the economy class seating to de-densify.



Artwork

Public art is often deployed to gently encourage passengers to **move towards** or **linger** in a space.



DESIGN DECISIONS

Planners deploy a range of strategies to guide passenger movement through the complex spatial sequence of airport terminals. Though no two airports are alike, the strategy at most airports can be distilled to one of just a few conceptual approaches, namely districts, connectors, streets and landmarks[2]. Regardless of the specific wayfinding strategy, a variety of devices can be used to guide passengers through space, including visual media like signage and maps, and architectural features like corridors and escalators. One of the most subtle interventions is the careful placement of public art.

In contrast to the direct, explicit communication of signage, **artwork can gently encourage passengers to move towards or linger in a space.** It can operate as a landmark at multiple scales - often serving as a distinct visual landmark in terminal interiors dominated by text, signs and pictograms, but also an indicator of the airport's geographic location.[1,3] In fact, while artwork often figures prominently in the design of a terminal, it rarely exists for the sake of the work alone.

In Qatar's Hamad International Airport, Urs Fischer's 23-foot tall "Untitled Lamp Bear" (previously installed in front of the Seagram Building in New York City) marks the entrance to the airport's duty-free shopping area.[4] In Vancouver's YVR, planners installed a number of artworks with region-specific themes as navigational aids.[5] In each case the artworks, along with several others exhibited in each airport, figure prominently on wayfinding maps in the airport. Vancouver is notable because airport planners designed the interior of the terminal based on where the artworks would be placed.[5]

Figure 1: Qatar Airport's "Untitled Lamp Bear", artwork by Urs Fischer

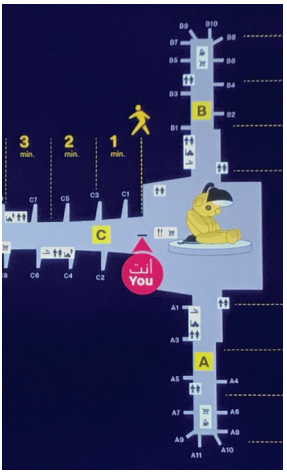


Figure 2: This bear figures prominently in wayfinding maps in the airport

EFFECTS ON PASSENGERS

Beyond an aesthetically pleasing visual landmark, **artwork can also subtly guide passenger consumption habits**. Airport planners "often choose eye-catching artworks to entice passengers to move towards shops and restaurants. However, they also select artworks that convey themes which they believe will stimulate consumption. In many cases, these artworks refer to the region where the airport is located. These objects are suspected to lend to the terminal's 'sense of place,' and airport authorities presume that this manufactured ambiance places passengers in the mood to spend".[5] Though one study found that passengers exhibited a slight preference for terminal designs that did not reflect the distinctiveness of a particular location (in this case Holland, which was conveyed with "an artwork referring to a clog, big cows, and Delft blue tiles"), the artwork in question was not a context-specific work produced by a professional artist, as is typically the case in the real world.[6]

Hubregtse's research on airport art has identified **kinaesthesia**, or **awareness of bodily movement**, as a **theme often found in various works.**[1,5] This theme of free, unfettered corporeal motion stands in contrast to the carefully controlled, highly regimented sequence of processing activities that all passengers are required to complete. Peter Adey has argued that this **symbolic representation of free movement** is designed to operate on an affective level, soothing passengers and by extension encouraging commercial spending.[7] Recent examples include Singapore's Jewel Changi Airport, which is organized around the Rain Vortex, the world's tallest indoor waterfall and New York's La Guardia Airport Terminal B, which includes multiple movement-themed works such as Sarah Sze's "Shorter Than the Day", an ethereal, mobile globe and Jeppe Hein's "All Your WIshes" a collection of 70 steel balloons attached to the ceiling along a sinuous path through the terminals retail area.[8,9]

Though its function can take many forms, the subject matter of airport artwork has its limits. Air travel can be a stressful experience for passengers, and

airport stakeholders are keen to avoid upsetting passengers as they move through the terminal. For example, in 2004 Denver International Airport (DIA) removed portions of "The Luggage Project" from public view. The work, in which artist Max Yawney invited an international collection of artists to turn 43 suitcases into art, included three suitcases that were deemed "too stressful" for passengers because of the imagery they evoked, such as a handle made from a box cutter, and a suitcase splattered with blood-red paint.[10] Other artwork at DIA has prompted conspiracy theories about a "sinister influence" at the airport, particularly the mural "Children of the World Dream of Peace," by Leo Tanguma.[11]

Figure 3: Singapore's Jewel Changi Airport uses the Rain Vortex as both artwork and as a spatial orientation strategy. Photo credit Safdie Architects

Bag Tag

Current bag tag system contributes significantly to the amount of time passengers wait in line at the airport

DESIGN DECISIONS

Baggage handling systems commonly use reinforced paper baggage tags **to know where a passenger's luggage is in the airport,** and to determine its intended destination. Using barcodes or RFID chips, these tags identify the luggage with its owner, the flights, and final destination, and even the class of service to indicate priority. This helps airports and carriers identify and trace a specific bag that has gone astray, and help the passengers prove the identity of their bags among other similar bags.

After the bombing of Air India plane in 1985, the airline industry developed a standardized **baggage tags system as a security measure** and required that bags were matched with their passengers before being loaded onto the plane. This was developed to ensure that terrorists do not check their bags with explosive material onto a flight without actually boarding it themselves.[1]

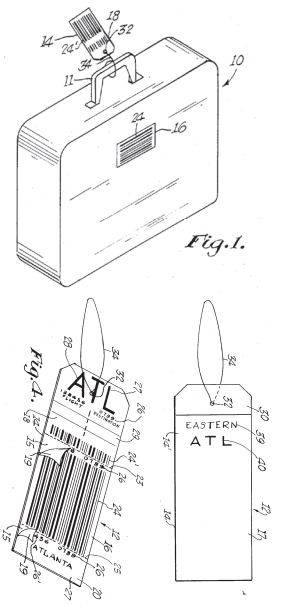


Figure 1. Patent filing for a baggage tag system from 1987, soon after the 1985 bombing

EFFECTS ON PASSENGERS

A major consequence of the baggage tag system as it exists today is that **it contributes significantly to the amount of time passengers wait in line at the airport.** In anticipation of this waiting time, people develop a variety of strategies. One such tactic is using carry-on bags rather than checked luggage, so that there is no need to wait in line to check and tag a bag. Another tactic is to arrive several hours in advance of flight time.

WHAT IF?

What if there was no need to wait in long lines to check a bag?
Similarly to the concept of mobile check-in for passengers, the luggage could be electronically checked-in long before even leaving the home or the hotel. Companies such as BAGTAG have been pioneering in this sector. Instead of attaching a paper tag, BAGTAG attaches a small electronic screen on the luggage that can display the barcode information, and be reused and updated for any subsequent flights.[2, 3]

What if bags were tracked similarly to package delivery tracking?
Korean Air has created an app where notifications are sent to the passengers' phone that informs them when their bag is loaded onto the airplane. The app provides a specific barcode to match to one's bag so there is little chance of a mix-up when claiming a bag.[4]

What if bags are tagged for sanitation?
Bags are in contact with multiple hands and surfaces which makes them susceptible for contamination. Airlines are considering adding a sanitation step when bags are dropped off at the check-in counter. The bags would be sanitized under UV lights and tagged for sanitation before they go through the security process and loaded onto the plane.[5]

Figure 2. BAGTAG attached on a luggage, which can be reused and updated for any upcoming flights.[2]

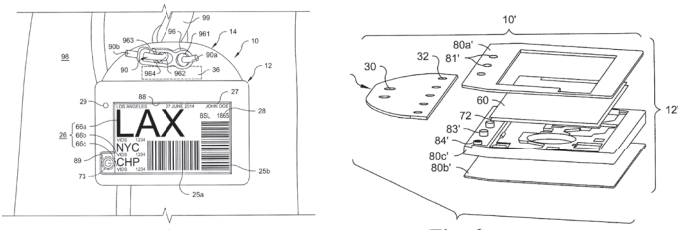
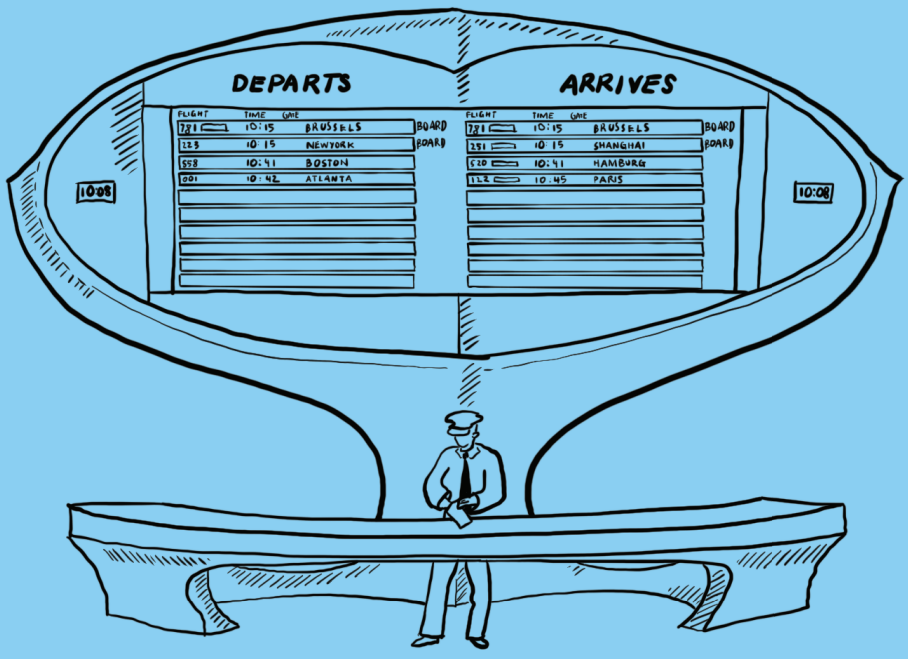


Figure 3. Patent filing for smart programmable electronic bag tag (2016)

Borders

An airport “functions as a national frontier… in the middle of a country.”[1]



International airports function in a similar way to physical boundaries between nations. They are "border zones to the vertical vectors of mobility that cross national and state boundaries... regulating the movement of people that enter and leave." [2] **These borders can take many forms, from not only physical but also non-material, to even emotional**, as expressed in the following quote:

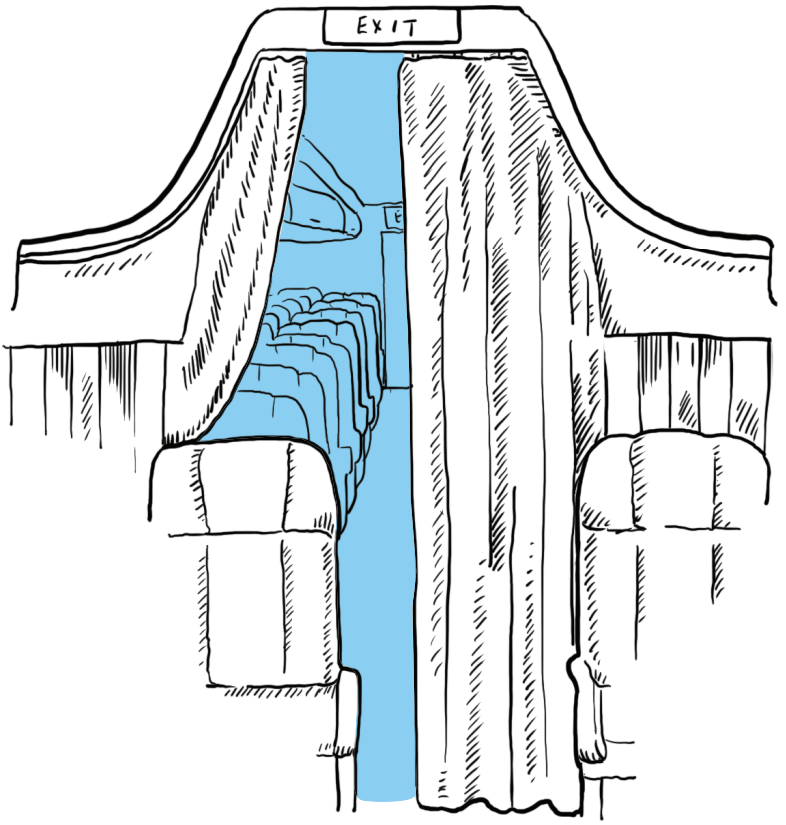
> "[L]andside-airside boundaries are socio-technical objects that are often materialized physically as a line or a fence, or as an artifact such as a net, chain, or queue divider; they sometimes appear as a wall, as signage, or as a glass panel. They also shape as scanners, or ID documents, or metal detectors. These boundaries may also take non-material shapes such as routines, procedures, jurisdictional limits, the containment or "segregation" of passengers, or control demarcations of higher entities such as agencies, customs, or an assortment of police divisions. Boundaries may even be embodied in the psychological emotions such as the public perception of fear, scrutiny, or the invasion of privacy. But they are all socio-technical objects that have as their ultimate purpose the enforcement of the separation of entities, mainly between the realm of aircraft and the realm of persons." [3]

In the context of airports, borders are designed specifically to construct and channel the passenger experience. **Most airports carefully direct passengers through a fixed, linear sequence of spaces** from their arrival at the airport until they reach their departure gate. "Thus, passengers follow the usual procedures of checking-in, going through security control, waiting in departure lounge, going to gate, waiting in gate, boarding plane. Between these processing sites, corridors and walls are constructed to limit possibilities."[2] Once passengers pass security and immigration, they enter the **state of liminality**, being legally outside the country while still physically in the airport.

Various strategies have been deployed to control the physical manifestations of borders at the airport. Borders have the capacity to be at once strongly defined, but also mutable and ephemeral. One of the most common features identified in the literature are moveable partition systems, allowing for the creation and definition of spaces to serve specific needs. For example, a recently completed expansion of Ottawa Airport includes a system of partitions that facilitate adjustment of the number of domestic and international gates simply by moving the separation of the two types of traffic.[4]

Cabin Divider

Studies have shown that class-based division on the plane - manifested physically by the **cabin divider** - can lead to an increase in **air rage**.



DESIGN DECISIONS

Cabin dividers help separate passenger zones in the aircraft cabin between the **first, business, and economy classes**. Cabin dividers can be curtains, solid thermoplastic barriers, or a combination of galleys and curtains. Cabin dividers' role as separators between passenger classes came about after the end of World War II when a few US airlines began to offer Economy class seats for the first time. Until then, air travel was by default exclusive to the affluent and the famous.

One of the earliest formalized "sorting" systems of passengers was in the early 1930s.[1] Britain's Imperial Airways introduced two service classes on its London-Paris route analogous to today's Business and First class, "**so that the famous and influential might have an opportunity to avoid the company of their social inferiors.**" [2] From 1939 to 1945, most commercial flying was suspended due to World War II. When it returned after 1945, progressive reform policies in the US incentivized airlines to offer cheaper economy seats. Thus, "In order to physically and psychologically separate the high-yielding full-fare passengers from those in economy, cabin dividers and curtains were employed." [1] By the 1970s, the three cabin classes that are customary today, first, business, and economy, became standard practice.

Cabin dividers primarily serve as **acoustic, visual, and psychological privacy barriers** between the passenger classes. Studies have shown that they assist with lowering noise levels and softening sounds in the cabin, and designers have developed various product lines of sound-absorbing fabric, with an opaque inlay that prevents galley lights from disturbing passengers at night. Sound-absorbing curtains can cut down up to 18 to 53 db depending on frequency of the sound.[3]

Additionally, cabin dividers must satisfy a vast amount of functional and material criteria. Like all airplane components, they must be lightweight, occupy a

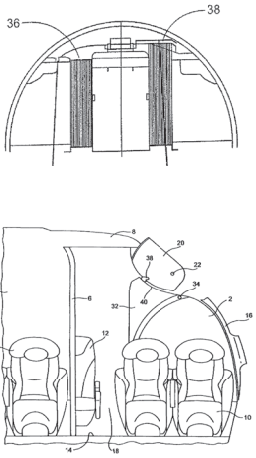


Figure 1. Cabin divider patent filings (2013, 2009).

minimal amount of space, and be flame retardant in the event of an accident. Thermoplastic cabin dividers are sometimes integrated with a jump seat, a foldable seat used by flight crew, and can be transformed to accommodate a stretcher in the event of a medical emergency. **TSA regulations require that curtains are open** during taxi and takeoff, in order to allow flight attendants and passengers a clear view of the whole cabin in the event of an emergency.

EFFECTS ON PASSENGERS

A cabin dividers, be it curtains, hard structures, or galleys, function as acoustic, visual, and psychological privacy barriers.

Acoustically, softening the ambient noise level in the cabin assists with lowering passenger environmental discomfort. There is evidence that **constant exposure to loud noises causes an accumulation of cortisol**, the stress hormone, in the blood,[4] which contributes to one's inability to control one's mood, motivation, and fear. Moderating loud or irregular ambient aircraft cabin noise is a useful feature of the cabin divider.

In a study conducted in a simulated aircraft, an increase in noise level was shown to have a significant impact on feeling more depressed, grouchy, irritated, anxious and nervous[5]. In addition, **noise level not only impacted one's acoustic discomfort, but also increased awareness of other non-acoustic aspects impairing comfort**, such as swollen feet, headaches, and tiredness.[6] It is important to note that the studies do not imply that the quieter the more comfortable. In a field study on a train, a level of "monotonous" noise was appreciated by passengers for masking other sounds[7].

> *The sense of hearing - ten times more sensitive than the eye in humans as well - is the most*

> *decisive warning and communications organ. This is why it remains open to the environment day and night, and is unable to deny access to sound stimuli in the same way as the eye with its lids closed against impinging light. This is the reason why sounds from the environment are constantly picked up, whether awake or asleep, and trigger massive stimulation of the processing sections of the brain...Noise effects are not only experienced as disturbing, irritating or stressful, but may also be associated with after-effects in terms of health.*[4]

Cabin dividers also serve as **psychological privacy barriers** between passenger classes. it remains more ambiguous whether cabin dividers are beneficial or detrimental. "The curtains that hang between service classes also operate as screens, permeable for the flight attendants, but not for the passengers, and shielding groups of passengers from fully realizing their differences as well as their similarities." [8]

It may be that cabin dividers function as symbols of the socioeconomic divide between first class, business, and economy passengers. Studies have shown that this **class-based division - manifested physically by the cabin divider - can increase conflict between passengers and incidents of "air rage**".

"Physical inequality on airplanes—that is, the presence of a first class cabin—is associated with more frequent air rage incidents in economy class. Situational inequality—boarding from the front (requiring walking through the first class cabin) versus the middle of the plane—also significantly increases the odds of air rage in both economy and first class." [9]

It remains to be seen whether cabin dividers help or hurt in exacerbating antisocial behavior arising from situational inequality. One point of note is that the study demonstrated an increase in antisocial behavior in both economy and first class, with "emotional outbursts" more commonly taking place among economy class, and "belligerent behavior" occurring more commonly among the first class. **Do the presence of cabin dividers highlight the situational inequality** of the class-based sorting of passengers, **or do they make the inequality less visible**? Or, by making it less visible, does the presence of the cabin divider give first and business classes an air of exclusivity that exacerbates antisocial feelings among all classes?

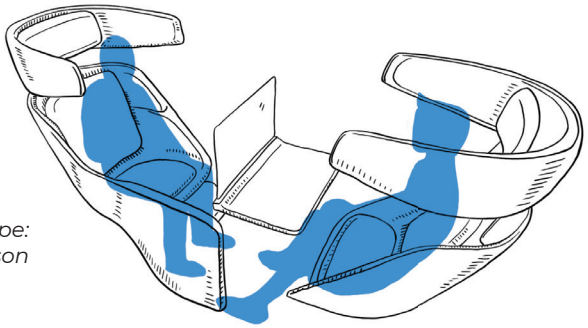
WHAT IF?

What if we reconsidered the way passengers are divided within the aircraft cabin?
Instead of organizing the passengers by class, it could be organized by usage types. These usage types might be family lounging, computer work, gaming, and sleeping. Airbus's Cabin Vision 2030 video shows such a proposal, showcasing dedicated spaces for five broad passenger personas: a young family, an elderly couple, a gamer, a business worker, and a sleeper.[10]

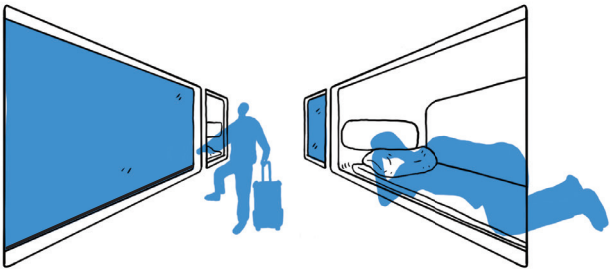
What if there were cabins for families with small children?
Sounds of crying babies are common sources of acoustical discomfort for many passengers. An area of the cabin can be dedicated to young families traveling with children, with sound-absorbent material integrated into cabin dividers, seating, or flooring. This would provide a noise buffer and a degree of privacy for those families and other passengers.

What if the lower cargo hold deck could contain common spaces for passengers?
Airbus and Safran's "Lower Deck Pax Experience Modules" proposes a system that uses the cargo hold to include modules for beds, areas for stretching, playground, or meeting spaces. Passengers in the main airplane cabin would have access to this lower deck for these various uses. These modules would fit inside existing aircraft cargo compartments. Multiple passenger modules would be designed in order to fit into the plane interchangeably and the baggage would be stored below or above the module.[11, 12]

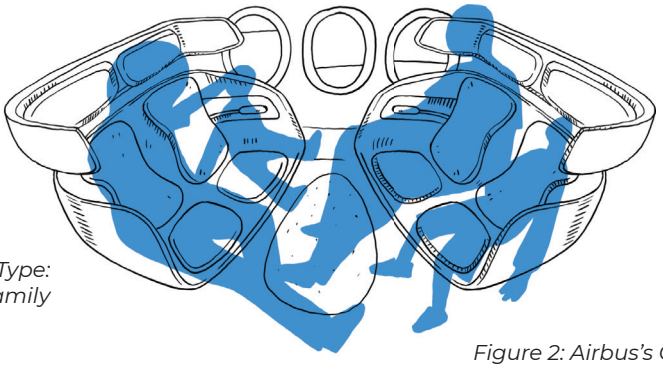
What if cabin dividers were created out of other materials to optimize weight and reconfigurability?
Installing solid fixed walls into airplanes takes up space and adds weight to the plane, but several sturdy cabin dividers may be necessary to hold jump seats for the crew. Autodesk's lightweight, 3d-printed latticed structure that acts as a cabin divider may be one solution.[13] The resulting divider is lighter, stronger, and more easily replicated than traditional fixed walls in current planes.



Persona Type: Business person



Persona Type: Sleeper



Persona Type: Young Family

Figure 2: Airbus's Cabin Vision 2030 video shows such a proposal, showcasing dedicated spaces for five broad passenger personas: a young family, an elderly couple, a gamer, a business worker, and a sleeper"

Check-In Counter

Airport check-in counters evolved from physical in-person counters to digital self-service kiosks, but now many seek to bring the human touch back into the check-in experience.

DESIGN DECISIONS

A passenger's first procedure upon entering an airport is most likely at the check-in counter, where their tickets and reservations are accepted, check-in bags taken, boarding passes printed, and special travel accommodations arranged.

Historically, check-in counters were staffed with human agents behind tables ready to assist travelers with their individual needs. As the number of fliers rose over the years, queues to these check-in counters grew out of hand, and airlines began to adopt online check-in options, or digital kiosks. Online and digital kiosk check-in allowed passengers to bypass queues.

However, in response to complaints about usability and customer service, numerous airlines have sought to **bring the human touch back into the check-in experience**, such as Delta Airlines's "Red Coats" program.[1] These human agents do not displace the automatic kiosks but instead work alongside them to provide technology assistance as well as addressing any special needs.

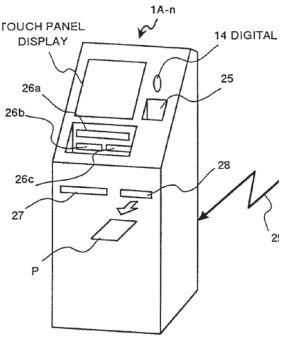


Figure 1. Patent for touch screen check-in kiosk

EFFECTS ON PASSENGERS

Websites, mobile apps, and self-service kiosks have expanded the number of available touchpoints for passengers to complete the check-in process, allowing passengers without special requirements to move quickly through the process and **giving passengers with special needs the ability to receive assistance with priority.**

The decision to move human agents out from behind the counter to alongside the passengers at these kiosks has also changed the relationship between passengers and representatives of an airline. There is a **lower chance for aggression** to develop when the person helping the passenger is next to the passenger rather than across and separated by a physical counter.[2]

Figure 2. Scene from Meet the Parents*:*

The main character becomes exasperated by an airline representative who declines to help him. The scene highlights how the physical separation of by the counter contributes to the hierarchy.

Figure 3. Scene from Computer says No! *by* Little Britain.

The main character, a travel agent in this scene, always responds to a customer's enquiry by responding with "Computer says no" to even the most reasonable of requests. The customer is left unable to dispute it, because of their inability to see the computer screen themselves.

WHAT IF?

What if check-in counters were replaced with biometric scanners?
Some airlines are starting to experiment with biometric and facial recognition scanners that allow for passengers to board planes without a passport or form of identification.[3] People may check-in online, drop off their checked-in luggage, walk up to security, and look at a camera. After two seconds, the camera confirms the passenger's identity and allows them access to enter the airport waiting area. Delta has implemented a facial recognition system in JFK airport which scans people prior to boarding. Privacy issues may be a concern with this new technology, as passengers are not in control of the information being given or handled by the controlling parties.

What if there was a way to share resources among airline companies?
The airport lobby is often filled with passengers and long queues, and hall allocation is typically not organized in the most effective use of space. Pooling collective resources among airline companies and having a single point of check-in may reduce the amount of stress experienced by the passengers.[4] Implementing a common-use self-check and baggage drop off system would improve the use of existing spatial capacity. Companies have already developed a block-chain system that allows passengers to scan their ticket and print a unique baggage tag for their respective airline. By sharing this resource, airports would also be able to defer expansion investments when new airlines are added.

Comfort

"Comfort is not simply the absence of discomfort, and indeed both can occur at the same time." [2]

Though related, perceptions of **comfort and discomfort can be understood as independent entities** that are associated with different factors.[1,2] Vink, et al. explains the following inputs as factors influencing human comfort and discomfort: history, state of mind, visual input, environmental factors (e.g. smell, noise, temperature and humidity), pressure distribution, and posture and movements.[3]

In the context of seat design, for example, discomfort is related to biomechanical fatigue while comfort is more associated with aesthetics and a general feeling of well-being.[2] In fact, people have difficulty distinguishing between seats of different ergonomics quality, due to the body's poor sensory feedback capabilities from ligaments, joints, and the spine, but will easily perceive and differentiate aesthetic features relating to comfort and relaxation.[4] In that end, **passenger perception may be more influenced by aesthetics and appearance of comfortable features than the specific ergonomic factors** of the seat design.

Passenger experiences can range from extreme comfort to extreme discomfort. The overall well-being of the passenger is influenced by physiological and psychological factors[5]. Some examples of physiological factors include sensory and environmental conditions (e.g. thermal, lighting, acoustics, etc.); psychological factors include concerns of crowding, speed of processing, security, and privacy.[1] Studies evaluating the passenger experience in the airport[6] and the aircraft cabin[7, 8, 9] have developed questionnaires to quantify passenger preferences, and mapping systems that classify and weigh the various factors against one another.

In the airport, psychological comfort was strongly influenced by attributes such as seating, crowding, speed of processing in queues, and anxieties surrounding security and passage of time. Among environmental factors, **thermal conditions** ranked as one of the most important parameters of indoor physiological comfort, followed closely by **lighting**

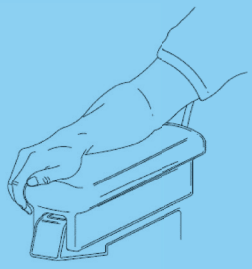


Figure 1. The armrest, and the ambiguity of who gets to use it, is a commonly noted source of discomfort.

Above is a patent drawing for a highly specialized intervention - a product that widens the armrest that passengers may bring with them.

Thermal condition is an example of a quality that contributes more to discomfort than comfort.

It is extremely important until it is satisfied, and then it is completely forgotten.

conditions, and then **acoustic environment**, **air quality, and humidity** levels.[6] Because of the nature of air travel, where outdoor temperatures dictate clothing levels worn indoors, and passengers may be going to or from vastly different weather conditions, thermal comfort proved difficult to achieve by following typical architectural guidelines for indoor spaces. Thermal condition is one of those factors which contribute greatly to discomfort, but less so to comfort; Thermal comfort is extremely important until it is satisfied, and then it is completely forgotten and not prioritized.[2]

In the aircraft cabin, passenger surveys have specifically highlighted proximity to neighbors, perception of hygiene, and crew attention as key psychological factors determining one's comfort.[7, 10] In particular, **invasion of personal space** is a critical source of discomfort for aircraft passengers. While many of these invasions often take the form of physical encroachments, other types of sensory factors, including smells, noise or eye contact contribute to the accumulation of discomfort.[11]

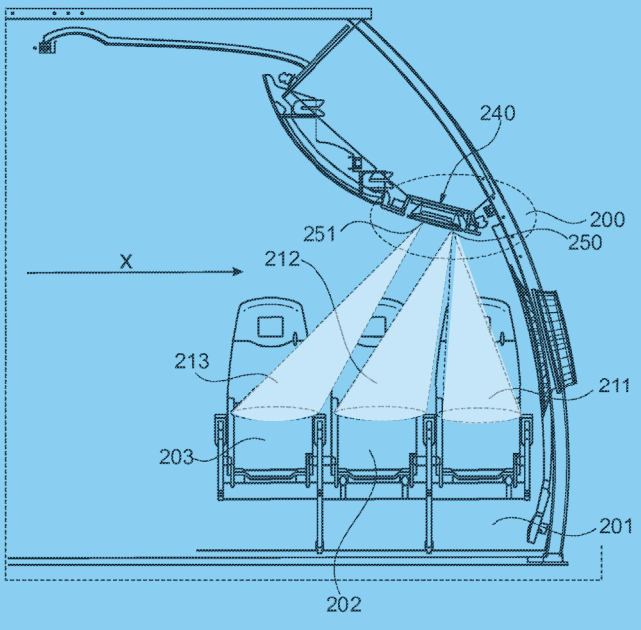


Figure 2. This mechanism allows each individual to control lighting independently from their seatmates.

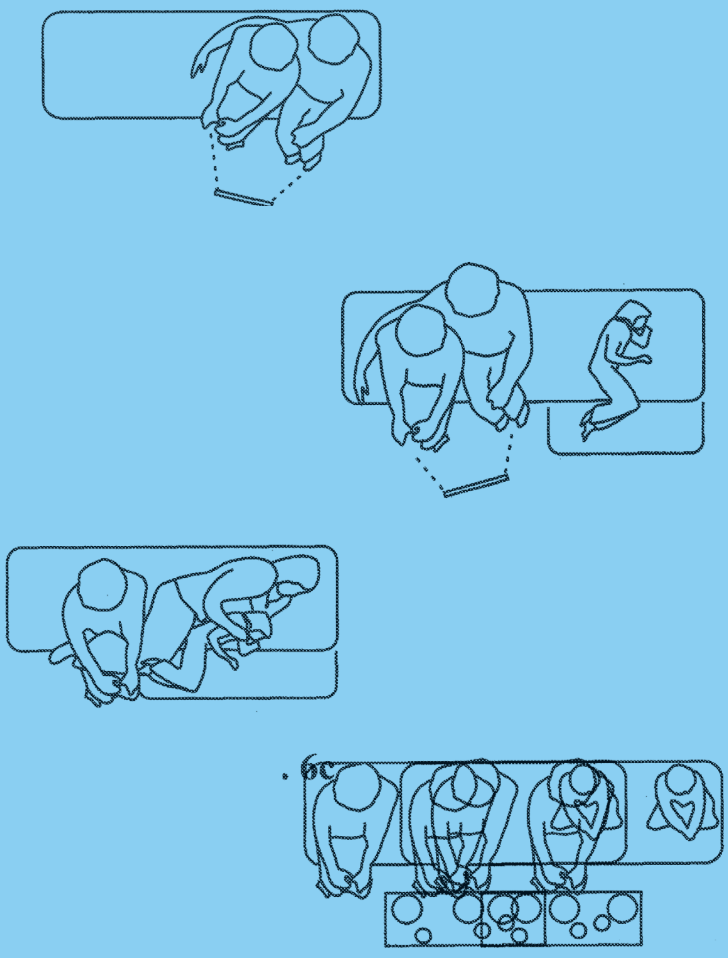
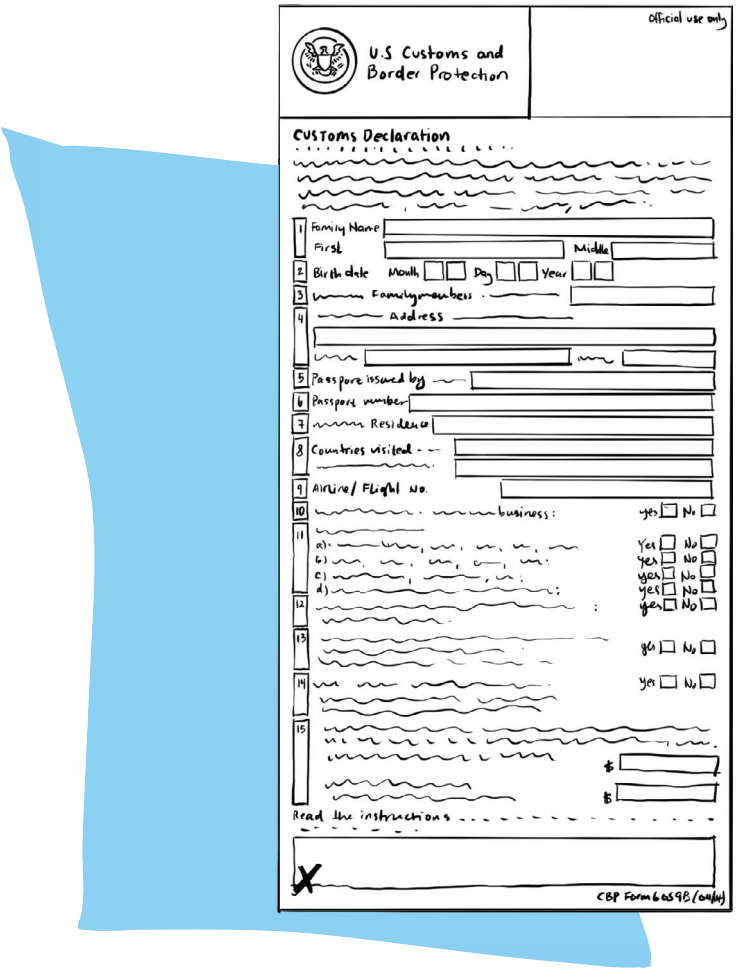


Figure 3. Using inspiration from how families use a couch at home, these diagrams imagine how triple seating in airplanes could be used by a family to maximize comfort.

Customs Declaration

Customs declarations and other such forms can be understood as “tickets” that allow (or forbid) a traveller to spatially progress.



DESIGN DECISIONS

When arriving from a different country than the destination, passengers must answer a number of forms and questionnaires. These include a customs declaration and an arrivals card, and may be accompanied by interviews with immigration officials.

A **customs declaration form** lists the goods that are being imported from abroad, such as alcoholic drinks, tobacco, animals, food, plants, seeds, soils, and meats.

An **arrival card** is a document used by immigration authorities of many countries to obtain information not provided by the passport, such as health, criminal record, purpose of the visit, etc.

These are submitted to officials at the port of entry, and sometimes accompanied by **interviews or secondary screening**. This secondary screening can involve questioning and searches by customs and border protection officials for an undetermined amount of time, in a secured interrogation room within the airport.

These written and verbal questionnaires can be understood as “tickets” that allow a traveller to advance to the next stage of a predetermined linear progression.

The process of going through the Customs and Border Protection inspection requires the traveller to literally walk over from one jurisdiction to another (See Figure 1). In this way, borders are made manifest and experienced quite spatially, where small pieces of land on which one is standing is designated as having a different legal jurisdiction from another.

EFFECTS ON PASSENGERS

Checkpoints with forms, questionnaires, and interviews contribute to the amount of time waiting in lines at the airport, creating boredom and frustration for many passengers. More significantly, however, this checkpoint can be a **significant source of anxiety and distress for people of certain demographics** who are more likely to be selected for in-depth interviews or secondary screening. These can be people from minority groups, religious affiliations, or professions such as journalism, activism, or politics.[1, 2]

Rights that are guaranteed by law can be suspended at airports because of the ambiguity of legal jurisdiction at borders. In the United States, the Supreme Court has yet to rule on the legal productions provided to American citizens reentering the country from abroad. Because of this ambiguity, the Customs and Border Patrol (CBP) has decided that it may conduct any search of any person, belongings, or electronic devices without a stated reason, and that it may withhold one's right to call an attorney. Warrantless searches of electronic devices have an additional consequence, which is that CBP can document any potential evidence in one's devices, such as email, social media feeds, photographs, and messages, and share what it finds with any other federal agency.[3]

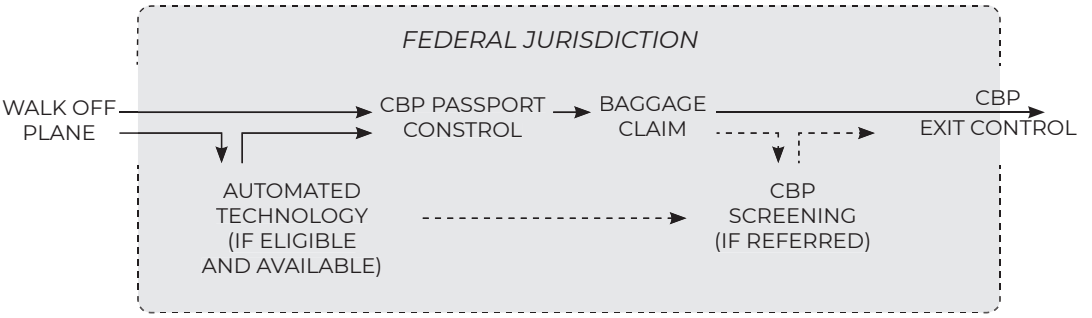


Figure 1. Customs and Border Protection (CBP) Air Traveler Inspection Process:

The process of going through the Customs and Border Protection inspection requires the traveller to literally walk over from one jurisdiction to another. In this way, borders are made manifest and experienced quite spatially, where small pieces of land on which one is standing is designated as having a different legal jurisdiction from another.

Departure Hall

"The airport departure lounge experience would appear to be the ultimate postmodern experience in which **all sense of time and place is suspended.**" [1]

DESIGN DECISIONS

Airport terminals are designed to guide passengers through a linear sequence of processing activities on their journey from the airport entrance to the departure gate.[2] Many of these spaces are designed to encourage a particular affective response, particularly the departure lounge.

Departure halls and lounges are designed to induce relaxation, and by extension encourage spending in commercial areas.[3] After passing through the compact, low-ceilinged corridors of security and immigration, the open space and high ceilings of a departure hall indicate to passengers that their air terminal journey is nearly complete.

The dimensional parameters of departure halls and lounges are defined by the number of passengers anticipated to travel through the terminal. Detailed **rule of thumb** standards have been published about their formal parameters.[4] **The hall and lounge should provide seating for 70% of passengers**, including seating at nearby concession areas, and a view of the airplane.[6]

Historically, the primary retailers present in the airport departure hall were those who could offer goods exempt from taxes and duties. However, the past quarter century has seen the rapid proliferation of available goods and services. Retailers have found in waiting air travel passengers **a captive, bored and affluent source of revenue.**[1] In recent years, the increased importance of commercial revenue for the profitability of airports has expanded the footprint

"It is recommended that, for each terminal departures lounge, the optimised/maximum dimensions, subject to busy hour rate demand are

A = 200 m maximum by B = 150 m maximum.

A common mistake made at many older airports is that the departures lounge is too narrow and, as a result, the retail space is long and narrow with insufficient retail shops to meet passengers' shopping requirements." [5]

of the departure lounge, and increased the amount of time that passengers are encouraged to linger there. In some large airports, the retail areas of the departure lounge can account for up to 20% of the total terminal area, though 8-12% is more common.[6] Regarding the design of retail space in departure lounges, Bradley states:

> *"The departures lounge retail space should ideally be on one level. If the departure lounge is split on multiple levels then there should be no more than two levels and it will be important to use the primary retail space effectively on the main level. Secondary retail space, including food and beverage and toilet facilities, should be located on the upper or mezzanine level within the departures lounge.*[5]

Some recent designs of retail spaces in the departure lounge reflect the distinctiveness of a particular location, such as recent improvements to Schiphol Lounge 3 by the design firm Studio Tjep.[8] The design has reportedly doubled passenger spending in Lounge 3.

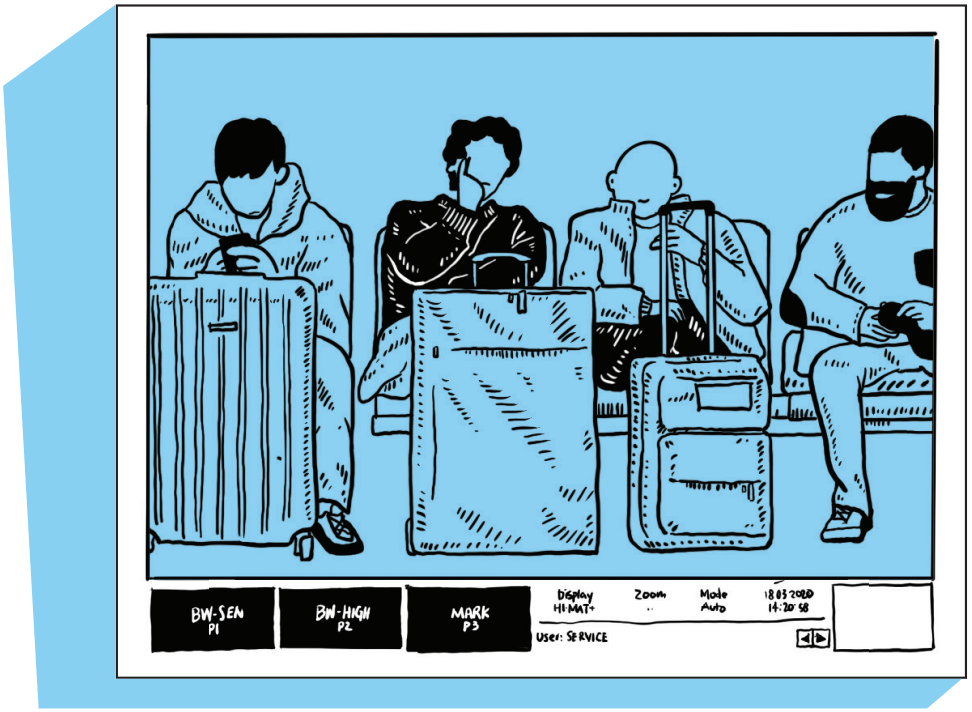
EFFECTS ON PASSENGERS

The departure lounge can also be seen as **an area for spectatorship**: An abundance of 'dwell time' can lead one to take an increased interest in "walkers and of the dramas occurring nearby." [9] Passengers will often locate their gate and then return to the departure lounge once they have a clear understanding of the time they have available.[6]

Rowley and Slack's study of airport departure lounges found a high degree of homogeneity across different airports, such as low-load environments, a consistent diversity of retail outlets, and internationally recognized brands.[1] **This homogeneity can contribute to a sense of "placelessness"** in the lounge environment.[7]

Detection Algorithm

Detection algorithms combines **CCTV footage with artificial intelligence** to monitor “deviant” behavior and movement.



DESIGN DECISIONS

With ever expanding growth of the air travel industry, airport authorities needed a way to surveil passengers without having to examine each passenger rigorously. For this, **three methods of sorting people** have been developed to effectively sort the most probable threat to security from other passengers. These methods, each of which builds on the previous, are:[1]

1. Profiling,
2. Biometrics, and
3. Detection Algorithms

1. Profiling is the act of building up data about an individual into "profiles," which are then compared against those of criminals to predict a person's likely criminal or deviant behavior. Profiling relies upon vast quantities of information gathered about people and groups that are then shared, and involves sorting and identifying people by demographics (such as race, age, geographic origin, etc). In the US, this method was introduced following the TWA crash of 1996.[1]

2. Biometrics introduced a new and more granular method of sorting, ushered in by technological advances. It refers to the ability to track each person by identifying body parts, such as the iris, face, and palm signatures. In combination with profiling, biometrics allows the profiles stored about each individual to be summoned easily at checkpoints. (See: *Passports*)

3. Detection algorithms, also known as *artificial intelligence surveillance*, is the latest and most technologically sophisticated of the three.[2,3] These algorithmic surveillance tools analyze real time CCTV and security camera footage, in order to look for and

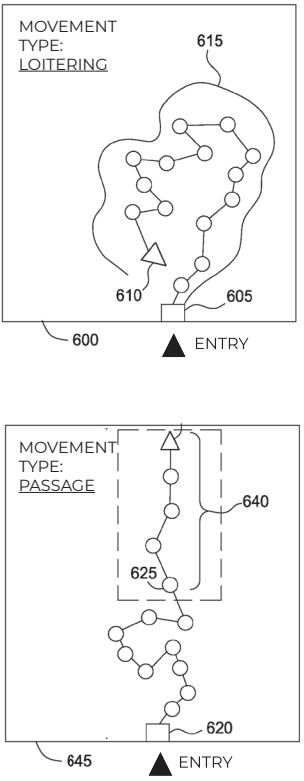


Figure 1. Patent filing for a loitering detection video surveillance system.

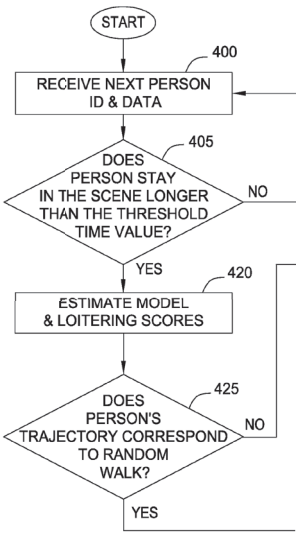


Figure 2. Examples criteria used by the surveillance algorithm software to track loitering and movement.

flag any potentially deviant or threatening movement among the passengers. To give an example, a technology currently widely used at US airports is called "Exit Sentry", which monitors the movement of passengers walking through the exit corridor of secured areas of the terminal. A passenger walking the wrong way, or trying to enter a secured area is warned with a flashing light. If the person persists, a siren alerts security staff[1].

Algorithmic surveillance can be understood as a way of identifying the **intent to do harm**, rather than identifying the **capacity to do harm**. These technologies focus on monitoring the movement of people as suspicious or potentially deviant. In contrast, methods that identify the capacity to do harm include X-rays and Full Body Scanners. (See: *Full Body Scanner*)

These **three methods of sorting people build upon each other** and are used in combination. For example, detection algorithms add additional information to the pool of data collected for biometric surveillance, such as gait recognition, which seeks to identify the identity of individuals by their distinctive walking styles. Or, a passenger flagged by the detection algorithm could be detained by security staff, biometrically identified by fingerprint, and have their profile summoned in order to assess the level of security risk.

EFFECTS ON PASSENGERS

Detection algorithms could be seen as both potentially more convenient for certain passengers, and more concerning for passengers' civil liberties.

This surveillance method lessens the pressures at security checkpoints on both passengers and staff, as it **makes surveillance a less visible presence** in the airport. It is possible that further development of this technology could help erase the spatial chokepoints in the terminal, and allow for more expedited passage through the airport.[4]

However, **it also raises a slate of civil liberties concerns**.[5] Although it is well documented that biases and prejudice can significantly affect algorithmic systems through its human developers and users [6,7], algorithms are often seen as 'impartial'. For certain populations, such as Arabs, Muslims, and Latinos in the US, **detection algorithms can be seen as a "license to harass."** [8] There is a risk that human developers inadvertently teach algorithms to flag mannerisms and behaviors more prevalent in minority groups as 'suspicious', and that those detection algorithms would further perpetuate harmful racial or religious profiling.

Additionally, **scientific research has undermined the premise that behavioral cues can indicate deception at all**: "Liars do not seem to show clear patterns of nervous behaviors, such as gaze aversion and fidgeting... People who are motivated to be believed, look deceptive whether or not they are lying." [6] The available research indicates that sorting potentially dangerous individuals through behavior observation is little more reliable than blind guesswork.

Duty-Free Shopping

"A passenger terminal has gone from being a little more than a bus stop to a two-hour check-in scenario... Passengers need services while they are in a 'hold' situation and **one way of paying for the increased security costs** is to expand the earning of **commercial revenue.**"[1]

DESIGN DECISIONS

During the period of discretionary activity, or *dwell time*, a primary (revenue driven) goal for airports is "to direct all passenger flow past shops... integrate seating areas to encourage passengers to remain in commercial space... [and provide] adequate flight information screens to keep people informed in the trading areas." [1] In other words, "**airport authorities attempt to create spaces where passengers are more likely to spend money and time**, and they do their utmost to hold them there." [2]

"Major international airports are nothing short of international shopping malls. London's Heathrow Airport, for example, comprises of 66,000 sqm of retail space." [3]

One of the primary design goals of these spaces is to ensure that passenger stress levels remain low, to create a general sense of ease. Airport stakeholders know that "...the moment you feel comfortable, you'll take some time to relax and you'll buy some coffee or perfume." [4] For instance, creating **a close physical link to departure gates reduces passenger concerns about boarding** their flight in time[5]. Subtle applications of artistic ceiling designs or flooring patterns can also contribute to keeping passengers in a retail environment longer.[6] Most airports (75%) use a single vendor for duty free sales, whereas for the other types of retail, nearly all (96%) prefer multiple entities.[7]

EFFECTS ON PASSENGERS

Consumers in a positive mood evaluate products more favorably than those in a neutral mood.[8] Retail products are also more appealing in a more pleasing space.[9] The unique range of emotions that travelers may experience at an airport, including anxiety, stress, and excitement, make them prone to act differently than typical shoppers in an ordinary retail situation.[10]

One unique aspect of airport shopping is the anonymity provided by the airport. Socially undesirable shopping habits, such as impulsive purchases of goods, can be facilitated by a feeling of anonymity. As a result, **nearly 70% of airport shopping is done on impulse** - where shoppers have no prior intent to purchase a specific brand, or even category of item.[11]

A 2011 study of 115 commercial airports found that, on average, a departing international passenger spent $26.80 on duty free shopping.[7] The most commonly cited reason for browsing in airport shops was “to fill in time.”[12] The reason for travel, duration of the trip, location of shops, knowledge of a particular airport, size of traveler group, and whether a passenger is flying on a low cost carrier have all been found to impact purchasing habits.[3]

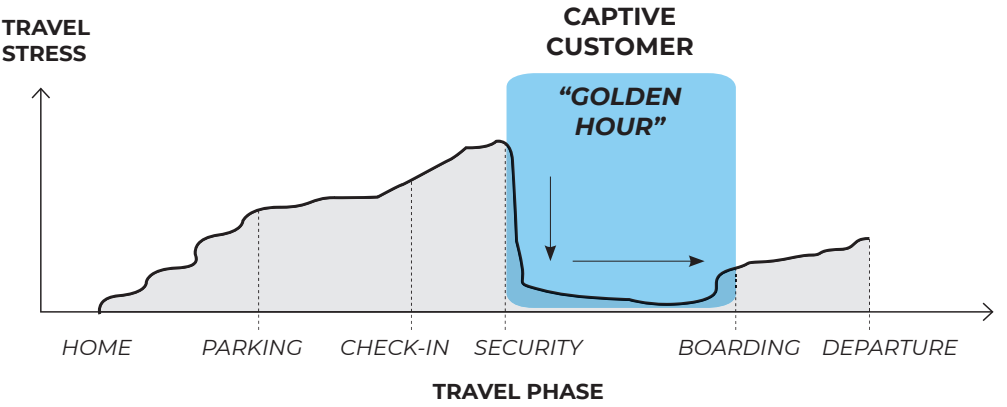
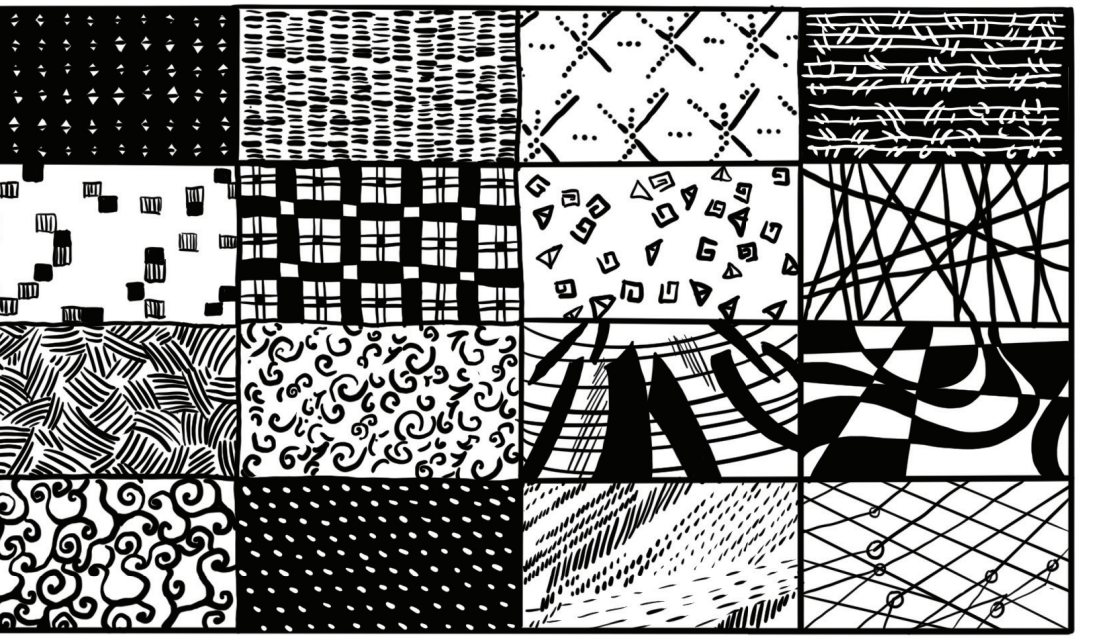


Figure 1. Passenger's travel related anxiety through time.

Highlighted region represents the time when they are most likely to participate in impulse buying.[2]

Floors

Material design decisions, such as whether a floor is carpeted or tiled, can define areas of **movement** or **stasis**



DESIGN DECISIONS

Terminal planners often select materials and designs to **encourage particular types of movement within the airport.** For example, security zones—spaces engineered to control and confine—are often dull, with low ceilings and circuitous pathways through a network of barriers[1]. In contrast, expensive, reflective materials such as polished limestone flooring are often deployed to facilitate unstructured movement and exploration within the terminal. This choice is predicated on the belief that reflected ambient light will positively impact a travelers emotions and encourage wandering in an area populated with shops and restaurants[2]. One particular example is the resin-stone conglomerate tiles in Heathrow's Terminal 5 (See Figure 1). These highly reflective tiles clearly reproduce the bands of light entering from a row of skylights that are arranged on the ceiling in distinct lines to guide passengers to the gate area.[1, 3]

Figure 1. Reflective resin-stone tiles in Heathrow Terminal 5

Floor patterning can also be used to **visually emphasize important pathways and circulation routes**, such as the heavily striated flooring patterns of Schiphol Plaza in Amsterdam Airport[4] (Figure 2, 3). The Italy-based travel retailer World Duty Free Group implements a similar strategy in the walkthrough shopping areas it has implemented in airports such as Gatwick Terminal South, YVR, and Stansted, where the suggested passageway through each shop is demarcated with black tile, while the rest of the floor is clad in white tile.[1]

Additional **material design decisions**, such as whether a floor is carpeted or tiled, **can define areas of movement or stasis, encouraging travelers to walk or linger**. A common flooring material transition employing this effect occurs at the gates, where the floor material shifts from a hard tiled surface to softer carpet, and someone crossing this boundary could experience a change in the amount of friction between their soles and the flooring. As architect Juhani Pallasmaa has said, "architecture is the art of reconciliation between ourselves and the world, and this mediation takes place through the senses."

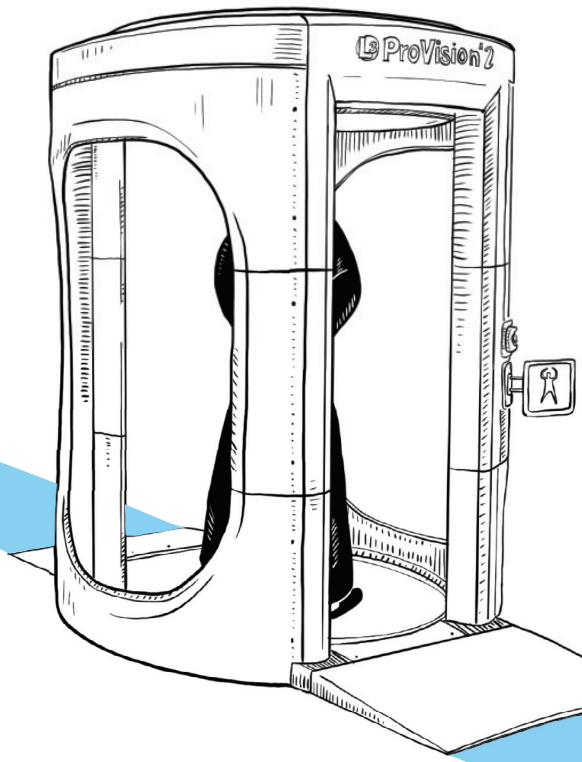
WHAT IF?

What if airport floors were personal assistants?
Smart flooring materials could recommend a path of travel for individual passengers. For instance, a de-planing passenger could be directed to their baggage claim via a bespoke illumination pattern. The force of a single person's step is enough to power the LED mechanism within the flooring panel, while excess power can be stored for future use[5]. This technology could be used to help create a guidance system for people who are lost or visually impaired. Floors with built in sensors can also detect physical trauma, such as when someone has fallen due to a medical condition.[5]

Figure 2. Striated flooring patterns of Schiphol Plaza in Amsterdam Airport that urge movement and directionality

Figure 3. Striated flooring patterns of the lounge areas in Amsterdam Airport that distinguish areas of movement and areas of rest

Full Body Scanner



Full body scanners are used for the screening of bodies, while x-rays are used for the screening of luggage.

DESIGN DECISIONS

Full body scanners, also called *Advanced Imaging Technology* (AIT), is a device that scans passengers to detect whether they are in possession of any objects that could pose potential threats. Starting in 2007, its use is the latest in a long line of screening strategies, including metal detectors, pat-downs, and X-ray machines.[1] A security checkpoint will often combine full body scanners for **the screening of bodies**, with x-ray machines for **the screening of luggage.** This device uses millimeter wave or backscatter imaging technology to visualize the body of the passenger and any objects that may be concealed under their clothing, without physically removing clothes or making physical contact.

Through the years, **the full body scanner technology has evolved with respect to the way it visualizes the person's body.** Initial devices, especially the backscatter machines, showed an image of the person's naked body, whereas latest millimeter wave devices show a cartoon-like representation, or otherwise obscure the face, groin, or other identifying features of the passengers. As of present day, passengers may decline full body scanner screening in favor of physical pat-downs or removal of clothing, but TSA staff may still make full body scanner screening mandatory for some passengers.[2]

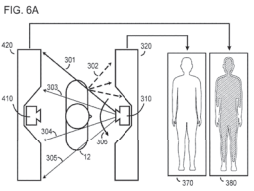


Figure 1. X-ray Transmission Imaging body scanner design (2012).

EFFECTS ON PASSENGERS

The deployment of full body scanners has spurred significant discussions about its effect on passengers' civil liberties. As Adey writes, **"A bag will not mind if it is x-rayed, CT scanned, and rummage through", but people do mind being searched and handled.**[3,4] It is seen less physically intrusive than pat-downs, but far more visually intrusive, with some calling it a "virtual strip search" without probable cause.[5] At Dallas International Airport, TSA complaints have been reported to disproportionately stem from women who felt that they were singled out for repeated screening for the entertainment of male officers[6]. In response to a variety of privacy-related complaints and lawsuits, the full body scanner technology has changed the way it visualizes the person's body, and various regulations have been developed regarding the recording and storing of images.[7]

Some privacy advocates see full body scanners as preferable to other methods that require the creation of large databases of biometric information and camera footage, since full body scanners are more discrete and momentary in deployment. Full body scanners assess **the capacity to do harm**, whereas other methods seek to identify **the intent to do harm.** Those methods, such as visual profiling by staff, or camera surveillance processed by A.I. algorithms (See: *Detection Algorithm*), run far greater risk of engaging in racial, gender, or religious discrimination.

On the other hand, full body scanners are a very highly visible deployment of security strategies, in contrast to profiling or camera surveillance methods which are relatively invisible. Thus, full body scanners can contribute significantly to **passenger anxieties surrounding being treated as potentially suspicious.** Advocates have accused TSA of using methods such as full body scanners to merely contribute to security theater, arguing that the relative ease of manipulating and hacking full body scanners prove that the body scans are ineffective and mostly for show[8] (See: *Security Theater*)

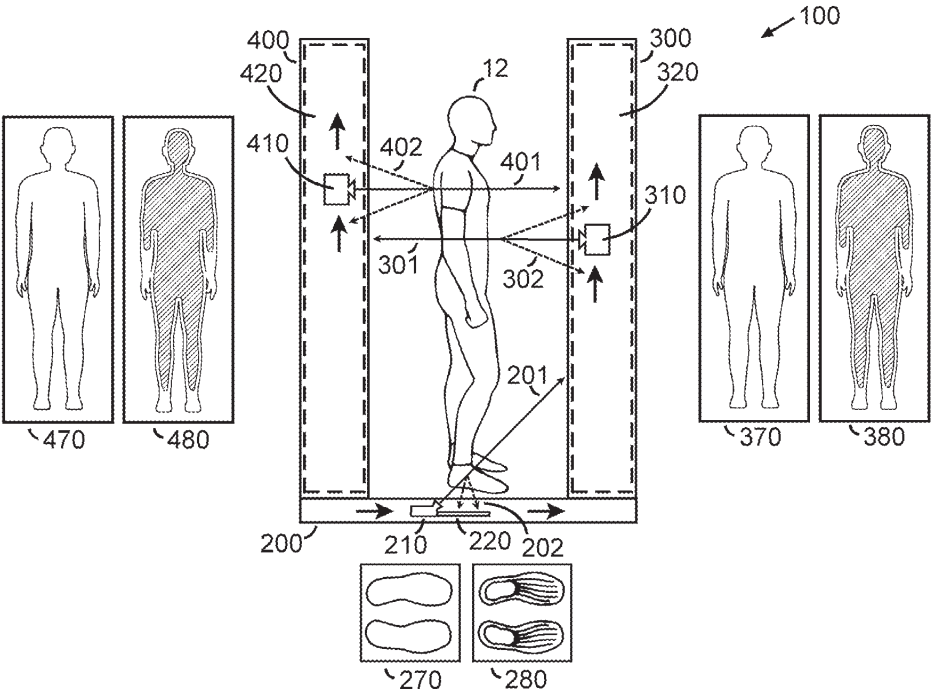


Figure 2. X-ray Transmission Imaging body scanner using backscatter technology (2012).

Gate Lounge

DESIGN DECISIONS

Gate lounges are often provided as assembly areas for passengers in transition from the main departure lounge and the aircraft, and are most commonly found in terminals organized as satellite buildings or with long finger piers.[1]

The scale of the airport influences the characteristics of the boarding gate. At smaller scale airports, it is typically not cost effective to have a dedicated lounge area at the boarding gate[1]. Seating areas that are shared by multiple gates can reduce space requirements by up to 85% over building a separate seating area for each gate, while simultaneously making it easier to shift a departing flight from one gate to another.[2]

Design standards for the gate lounge recommends that it is sized to accommodate the number of passengers expected to be in the lounge 15 minutes prior to departure, typically about 90% of the total number of passengers.[3] Reducing the time that passengers spend queuing at their gate means that passengers will tolerate higher occupancy densities.[4]

EFFECTS ON PASSENGERS

In their analysis of the departure lounge experience, Rowley and Slack observed that “US airports have much more of a sense of urgency and activity (or a “buzz”)” while in other parts of the world... the sense is more one of leisure and luxury, calm and relaxation”.[5]

Travelers in the United States are notorious “gate huggers”, an airport industry term that refers to travelers who proceed immediately to their gate once through the airport security checkpoint , rather than engaging with the ever-expanding array of retail and dining options in the departure lounge.[6] From the perspective of the airline industry, these passengers are less likely to spend money at food and retail outlets, depriving the airport of potential revenue. However, the trend for US travelers to congregate at gates more frequently may be influenced less by cultural preferences and more by the ownership structure of airports in the United States, in which processing facilities are owned by a central authority and concourses managed by individual airlines.[6]

On a global scale, various sources of anxiety are cited when explaining the tendency for passengers to congregate at their departure gate lounge, including nervousness about missing their flight, the threat of gate-checking a bag if they are one of the last passengers to board, or relatively informal boarding procedures of low-cost carriers.[7]

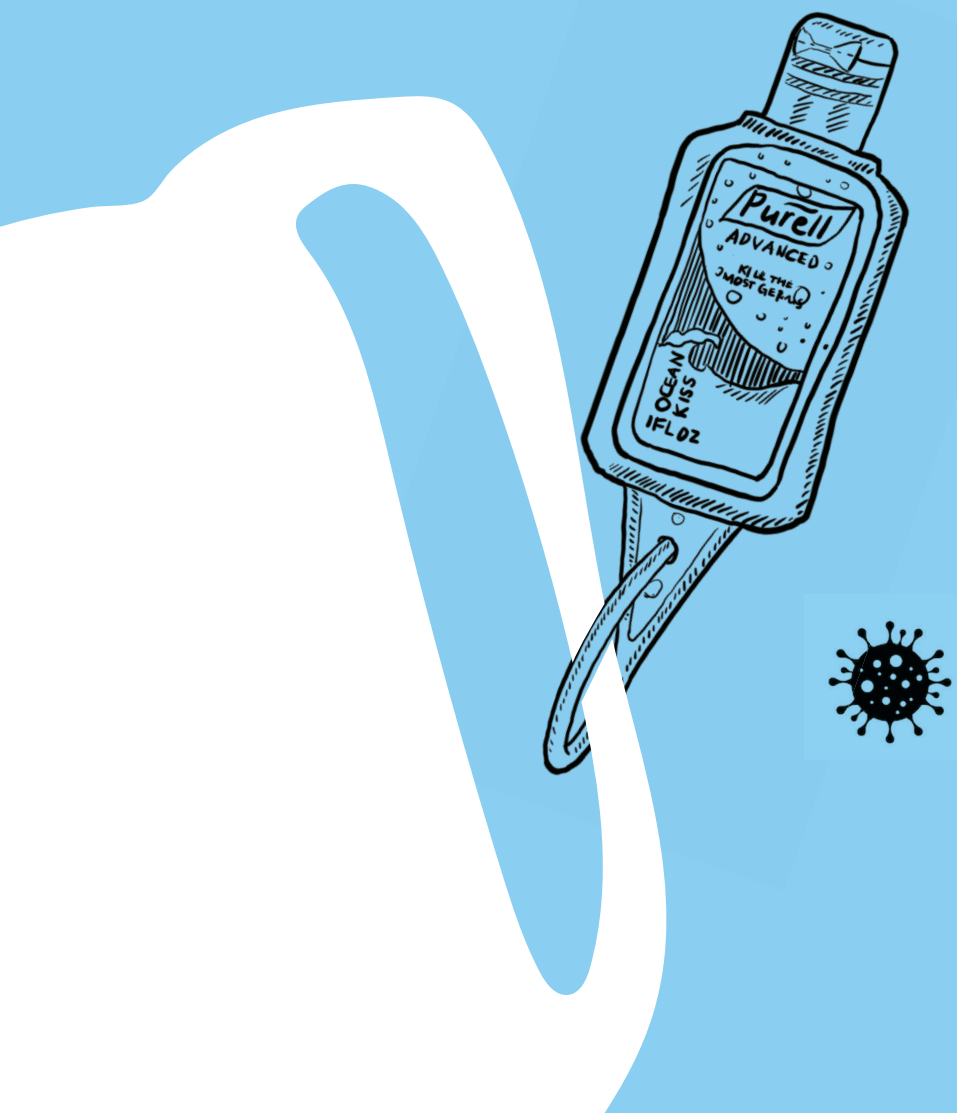
This phenomenon is common enough that such passengers have earned the nickname of “gate lice”;

Boston Globe gives the following jetiquette advice: “Don’t crowd the gate before your boarding group is called. In the travel world, we refer to people who block the gate as “gate lice.” A simple fix: If your boarding group hasn’t been called, don’t stand in line or block access to those trying to get on board.” [8]

Several startups have developed novel solutions to the gate hugging problem that do not rely on passengers physically occupying the main departure lounge. The food service company HMSHost has deployed mobile carts stocked with beverages, snacks and magazines to serve passengers at gates.[9] Startups such as AtYourGate and Airport Sherpa (now defunct) allow travelers to order gate-side food delivery from restaurants in other areas of the airport.[6]

Germs

The current pandemic's international spread is attributed primarily to air travel.



Air travel can have a number of physiological effects on the body, from jet lag and aches to swelling extremities. Environmental factors such as low humidity in the cabin air lead to dehydration, creating nasal or throat discomfort. The fear of being infected by an illness on airplanes has always been present, exacerbated by these bodily discomforts. But today, passengers directly confront the dangers of germs as never before, as the world navigates the current COVID-19 pandemic.

In 2007, an article in the The Journal of Infectious Diseases warned that, "Air travel can influence the global spread of emerging and established infectious disease. Infections may be spread on the aircraft through close contact and large droplets... Perhaps the greatest concern for global health, however, is the ability of a person with a contagious illness to travel to virtually any part of the world within 24 hours."[1]

Today, the world reckons with a pandemic whose international spread is attributed primarily to air travel. As a result of travel bans, governmental lockdowns, and passenger fear of air travel, airplanes have been emptied out of passengers, causing **financial damage far beyond the impact of previous epidemics such as SARS and MERS or events such as 9/11.**[2]

In order to reduce further spread of COVID-19 over air travel, airlines and airports have bolstered the routine cleaning procedures of aircrafts and terminals. Airports have also instituted screening measures including thermal cameras and social distancing, but studies have raised doubts about these methods, arguing that "**airport screening is largely futile.**"[4] Airplane cleaning seems to have a greater effect at limiting transmission. These cleaning procedures can be summarized as a three-pronged effort:

1. Sanitation of Physical Touchpoints
2. Air Circulation and Filtration
3. Social Distancing and PPE

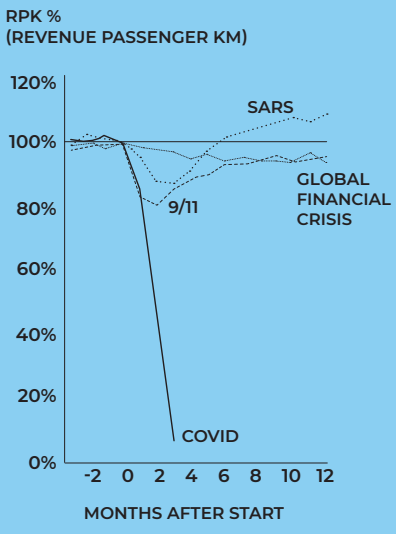
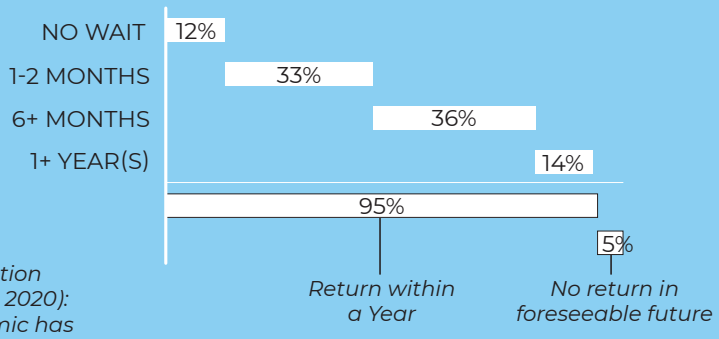


Figure 1: Depth of COVID-19 impact on the air travel industry far exceeds previous crises[2]

Sanitation of Physical Touchpoints

Airlines clean cabins to varying degrees between each flight, with international flights receiving more rigorous cleaning than domestic flights due to the longer time allotted for turnaround.[4] Since March 2020, airlines have greatly enhanced their cleaning policy, and health agencies such as the World Health Organization (WHO) and the Centers for Disease Control (CDC) have published updated guidelines for cleaning an aircraft cabin during the COVID outbreak.[5]

Before COVID, standard procedure between flights involved removing trash, switching linens, and wiping surfaces with an EPA-approved disinfectant. When the aircraft is done flying at the end of the day, crews would use this time to give the plane a deeper clean. Since COVID, cleaning protocols now include a closer attention to physical touchpoints, specifically seats, overhead air vents, door handles, tray tables, seatback pockets, and window shades. Most airlines have also started **spraying a high-grade disinfectant** inside the cabin after every international flight, called "**fogging**".[4] When fogging the interiors of planes with disinfectant, tray tables are lowered and overhead bins and lavatory doors are opened.[6,7] Some airlines, such as JetBlue, are also providing passengers with sanitizing wipes in-flight.[8]

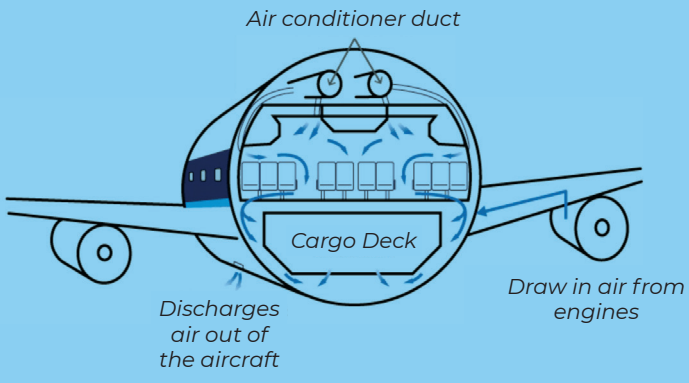


IATA Survey Question (conducted June, 2020): Once the pandemic has subsided, how long would you wait, if at all, to return to your usual travel plans?[2]

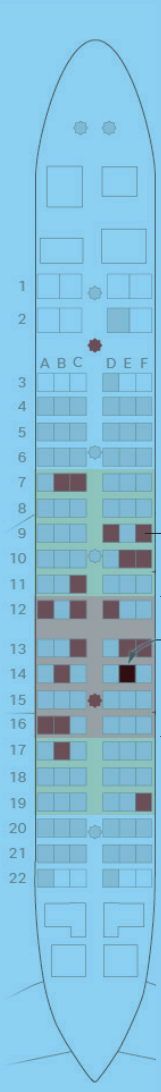
Air Circulation and Filtration

Air on planes is typically filtered through **high-efficiency particulate air filters, also called HEPA filters**. The air circulates until it is drawn into the lower fuselage, run through HEPA filters, and then re-mixed with a constant supply of fresh air. These filters capture between 94 to 99.7 percent of airborne microbes, and all of the air in the cabin is refreshed every 15 to 30 times per hour, a rate far more frequent than those in buildings.[9] These air circulation protocols using HEPA filters have already been in use for years throughout the majority of aircrafts, but now airlines are paying additional attention to their air filtering systems during COVID-19.

The overhead air vents for individual passengers, called "graspers", can also play a role in limiting the community spread of COVID-19. If a passenger is infectious, **turning on the overhead air vent can help contain his or her airborne microbes**. According to Vicki Hertzberg, a biostatistician who co-led a study on disease transmission with Boeing, the strong force of air attracts other air into it: "You're sneezing into that draft of air and it just immediately sucks it down to the floor."[10, 11]



PPE and Social Distancing



Distribution of SARS aboard a 3-hour flight, Flight 112 (2003)

Probable transmissions

Index Patient

Generally considered transmission risk zone

Most flight attendants are now required to wear masks and gloves, especially for those on international routes.[6] Masks are required for passengers currently, but this rule is not yet uniformly enforced and different countries have different cultural norms about mask usage.

Significant risks remain for both passengers and flight crew. All the rigorous cleaning protocols do little to help a passenger avoid an infection, if an infected person is within one's transmission zone. The WHO and the CDC's guidelines of social distancing states that people should keep a distance of about six feet from each other, but this can be difficult in airplanes where people are packed together in close proximity for long periods of time. Many airlines currently space out the passengers so that at least every other seat remains empty, in an effort to abide by the social distancing guidelines.

The **size of the potential transmission zone** is also hard to predict. Although it is generally believed that respiratory infection spreads in planes approximately two rows ahead of and behind the infected patient, actual transmission may go much further. In the case of SARS, a coronavirus outbreak from 2002-2003 with similar means of transmission as COVID-19, a single patient infected 18 passengers as far as seven seats away, much further than the zone considered a risk for transmission.[12, 13] In the case of the flu, studies of flu transmission in-flight have revealed that the **safest place to sit on a plane is by a window.**[14] "Statistically, people in window seats come into contact with fewer passengers because they leave their seats less often than those sitting near the aisle. And they are a few more feet from the action in the aisle, where passersby could be coughing, sneezing and spreading germs."[10] It remains to be seen what exactly might be the transmission zone of COVID-19 in-flight.

Social distance seating onboard, which allows 2/3 of max capacity

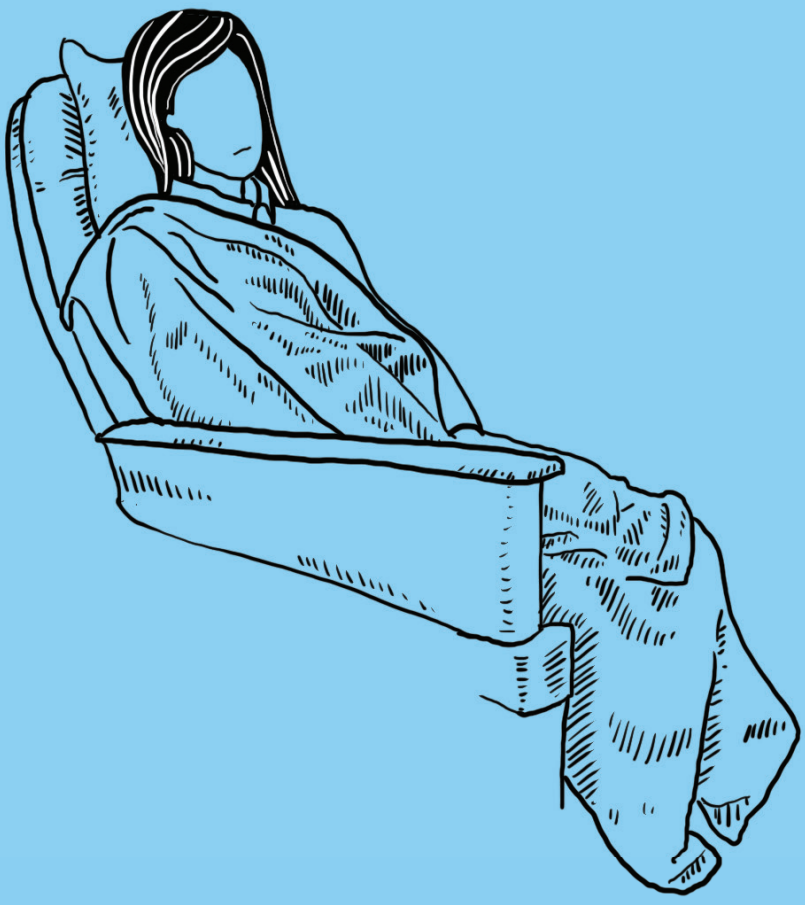
What if the industry took COVID-19 pandemic as an opportunity to rethink and address issues that were already present in the air travel experience? COVID-19 has exposed further inadequacies and inefficiencies in the air travel industry. In particular, the economic feasibility of air travel is dependent upon spatial efficiency, which is in direct conflict with the physical distancing required by COVID-19. How might the pandemic help us rethink some of the issues that were already present in the air travel experience?

Crowding is an issue at many different points of the air travel experience. "When boarding a plane, people are blocked and forced to stand near the person putting luggage in the bin -- people are very close to each other. This problem is exacerbated when many [boarding] zones are used."[12]

"Fogging" of high-grade disinfectant in aircraft cabin

Illusion Of Control

People develop routines and superstitions to give themselves the **illusion of control**.



One of the main reasons that passengers might find the air travel experience unpleasant has to do with feeling a loss of control. The passenger can feel as if they are at the mercy of nature, airport security personnel, or the airline cabin crew. They are directed where to go, how to move, and even when to go to the bathroom on the plane.

In addition, air travel subjects the body into physiological and mental disorientation unique to this mode of transportation. Time flows differently during air travel, as a T-minus countdown rather than an actual reference point to a time of day. Days stretch without an end, and one can end up eating three lunches in a row during flights and layovers. Circadian rhythm disruptions cause us to navigate spaces in an altered mental state.

In response, people develop various tactics to give themselves the illusion of control.

1. **One such tactic is by carrying out routines and rituals.** Many passengers develop pre- or during-flight routines and rituals. These range from conventional, such as wearing comfortable clothes or brushing one's teeth before flight, to superstitious, such as always stepping onto the plane with the right foot for luck, to truly idiosyncratic (See: *Ritual*).

2. **Another tactic is gamification.** Because of the spatial configurations and the nature of progressing through the different parts in the terminal, the passenger journey through the airport can feel like progressing through levels of a game. The airport is a unique type of architectural typology, where the spaces are subdivided and arranged to usher large groups of people to move unidirectionally. This encourages people to develop strategies to 'game' the system, and to feel competitive with other passengers moving through the airport. This also contributes to why passengers react with especially heightened emotions to events at the airport or in the airplane, such as feeling especially elated at being directed to a shorter queue, or feeling "air rage" at fellow passengers for small slights (See: *Jetiquette*).

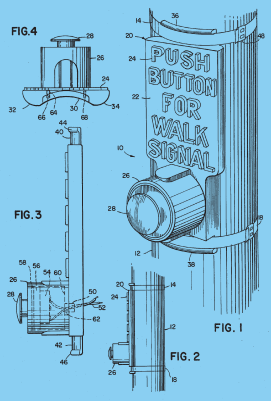
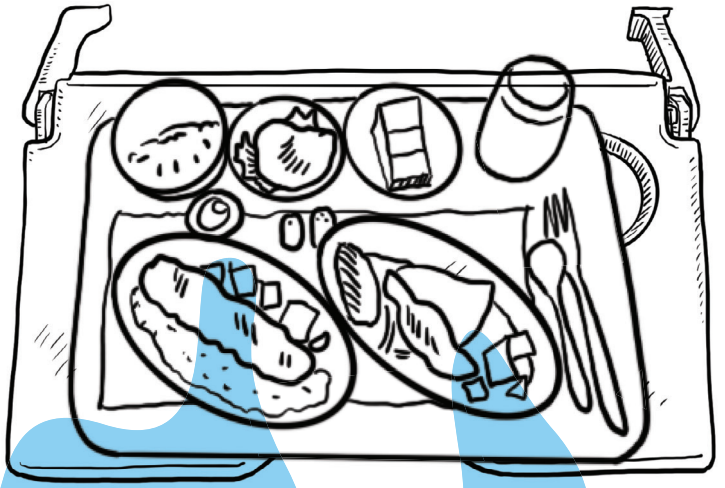


Figure 1. One example of a device that helps people feel an illusion of control, despite that in many places it does not actually operate. These are somtimes called "placebo buttons."

In-Flight Food

Passengers' perception of **taste and smell** change considerably in flight.



DESIGN DECISIONS

In the early days of commercial flight, in-flight food service consisted of cold items including ice cream, cheese, fruits, salad, and meats, and hot tea and coffee in thermos containers.[1] As airlines transitioned to larger kitchen galleys in the mid-1930s, regular hot meals became more and more common, with preparation on hot plates or pots with electrical heating coils.[2] By the 1950s, equipment in the galleys included several catering functions such as convection ovens, refrigerators, and service trolleys (See: *Meal Trolleys*). This enabled frozen meals to be kept in storage before being reheated in the ovens, greatly increasing the meal options available in flight.[1]

""Meal times on long flights serve to distract the passengers. Especially on long trips, they are an important way of dividing up the flight into manageable lengths of time." [2]

History shows that the development of the meals and the galleys happened hand in hand; improvements in the meal service system greatly increased the variety and quality of the meal options available on the plane. Yet, despite all of the advances of the contemporary aircraft galley**, the quality of airplane food is a frequent topic of derision today.**

A significant contributing factor is **the amount of time that must pass between food preparation,** heating, and service. The meals, prepared on the ground, endure hours of storage and transport.[3] Once in the air, the meals are reheated and then distributed to hundreds of people. The sheer number of meals being delivered requires intricate logistical coordination at every stage, translating to a seemingly unavoidable amount of time passing before the food reaches every passenger. As a result, most airplane meals are doused in fluids and sauces in an effort to help keep the food from drying out or going cold.[4]

EFFECTS ON PASSENGERS

"Ingredients such as cinnamon, ginger, garlic, chile and curry do not need as much adjustment and maintain the taste of the food... [It is] better to rely on naturally intense flavors, such as orange and tomato oils and tomato concentrate, instead of simply increasing salts and sugars." [4]

To better understand the widespread aversion to airplane food, numerous studies are being conducted to examine how the environmental factors of the flight cabin might contribute to our sensory experiences of taste and smell.

In 2010, Lufthansa commissioned the Fraunhofer Institute for Building Physics to examine how our perception of particular flavor profiles can change in flight. In the partial fuselage of a decommissioned Airbus A310 placed in a 30 meter long low pressure chamber in Holzkirchen, Germany, researchers had subjects record their enjoyment of different foods at a variety of ambient air pressures. The researchers found that **our ability to taste certain flavors is dramatically reduced in flight.** Changes in **air pressure** can reduce the sweet and salty signals to the brain by up to 30 percent, and the **dryness** in the flight cabin can suppress our sense of smell, an important factor in taste.[5]

*When travelers order a drink in-flight, **tomato juice** has proven to be a surprisingly popular option. Tomato juice, rich in umami flavor, is perceived as more flavorful and less acidic in the air than on the ground. Culturally, the tomato juice likely also gained an enduring association with flying from Amelia Earhart's endorsement and advertisements for Beech-Nut tomato juice in the early days of flying. In a radio interview between 1935 and 1937 when asked what pilots eat while on long flights, famed pilot Amelia Earhart said that tomato juice was her "favorite 'working' beverage--and food too!"* [8]

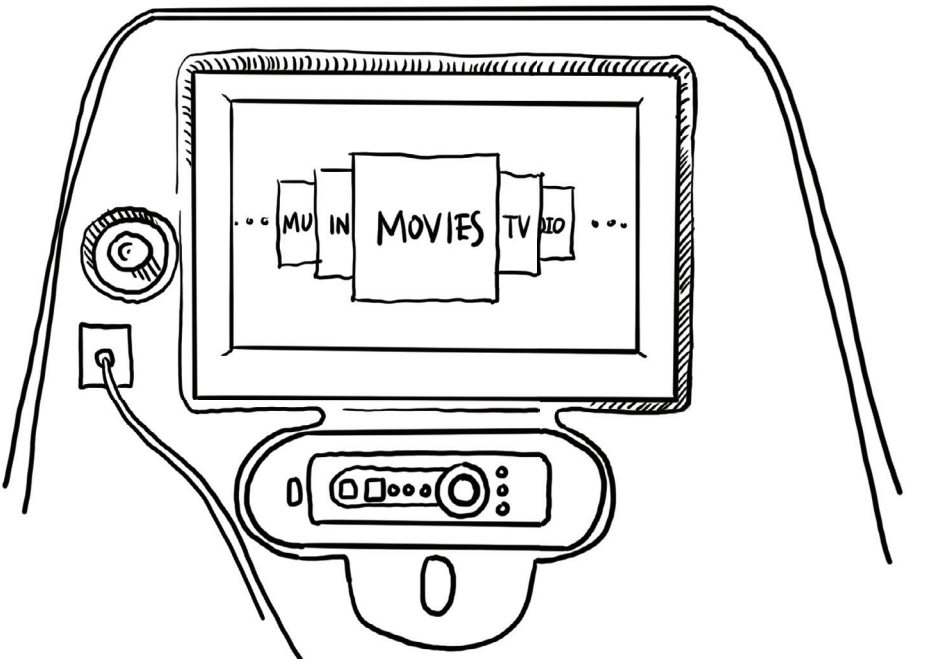
Changes in **noise** levels were also found to affect people's ability to taste flavors. A 2015 study from Cornell researchers found that **high decibel sound heightens one's preference for savory foods**, especially the umami flavor.[6] Umami-rich ingredients, such as seaweed, mushrooms, tomatoes, and soy sauce helped to provide a better taste and aroma experience. Given that the typical noise volume in an airplane in mid-flight is between 85 and 105 decibels,[7] the auditory levels of an in-flight cabin may contribute to our food and beverage preferences.

What if airplane meals reframed the relationship between the senses of sound and taste?
Taste tests in simulated aircraft environments have demonstrated that the high noise levels in the cabin decreases our ability to taste flavors. In order to mitigate this impact, British Airways introduced a synesthetic approach combining the sound and taste senses. Based on the research of Charles Spence, a professor specializing in the brain's integration of information across different sensory modalities, British Airways unveiled the "Sound Bites" initiative on their long haul flights in 2014.[9] The initiative paired playlists with the offerings of the airline menu so that sound may beneficially, rather than negatively, impact one's sense of taste.

What if passengers purchased meals at the airport to be eaten on the plane instead of having it catered on the plane?
In-flight catering involves a very complicated system of preparing meals based on flight occupancy and dietary restrictions. There are also concerns of hygiene, quality, recycling, and disposal. If meals were prepackaged and purchased prior to boarding, airlines need only be responsible for waste disposal. An example of this system is implemented on Japan's bullet trains. Passengers of Japan's bullet trains purchase lunch boxes to eat on the train called "Ekiben". Each destination has a different style of lunch box for passengers to enjoy. Waste is kept to a minimum and passengers are responsible for the disposal of their own trash when departing. A similar system could be implemented for short-haul flights.

In-Flight Screen

The screens on board the plane allows passengers **to look away**: from each other, from the risk and uncertainty of air travel, and from their boredoms.



DESIGN DECISIONS

Beyond technologies associated with the provision of basic human needs, such as pressurization and oxygen, the aircraft cabin has been a site for the development and deployment of screen technologies nearly since the advent of commercial flight itself. In fact, the first documented instance of in-flight entertainment occurred only 7 years after the first commercial flight.[2]

Screens often function as a welcome distraction, **encouraging passengers to distract themselves from the experience of flight**. They are intermediaries, shielding passengers from the realities of flight and the banality of long distance travel by keeping passengers entertained, calm and content. Currently, we navigate nearly all forms of in-flight entertainment through screens – whether the exhibition of films and television shows, the playing of music or video games, or the display of data relevant to one's particular flight. According to one recent survey, along with fresh food, in-flight screens have the greatest positive effect on customer satisfaction.[3] The value of in-flight entertainment has been a catalyst for developing increased connectivity in-flight.

We experience other types of screens in-flight as well. Windows in the main cabin screen passengers from inhospitable atmospheric conditions, and provide an oblique view of one's immediate surroundings. Other screens such as curtains, in flight magazines and safety cards can define our personal space, and protect from intrusions by fellow passengers. Inflight entertainment, then, is the cultural condensation of these contradictory impulses to bring the faraway closer (in place) but still maintain distance (through space).[4]

The basic arrangement and mode of interaction with screens can have significant implications for a passengers experience. The delivery method of In-flight Entertainment and Communication (IFEC) has evolved from a limited number of shared overhead screens, to individualized seatback screens, to a **Bring-your-own-device (BYOD)** model predicated on the existence of the prevalence of personal electronic devices and increasingly robust networks of wireless connectivity and communication.

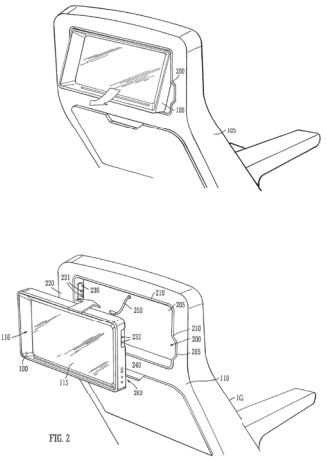
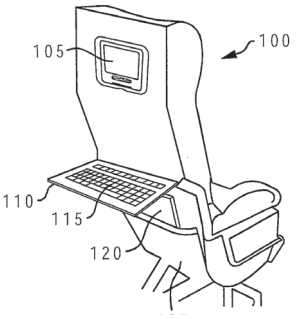


Figure 1. Seatback in-flight entertainment screen design

A recent survey of 7,900 aircraft indicates that entertainment is almost evenly split between the 3 methods (overhead, seatback, streaming.)[5] For every aircraft flying in the United States without IFE there are seven aircrafts that are.[6]

EFFECTS ON PASSENGERS



Figures 2, 3. A design to connect laptops to display on seatback screens (4) has become outdated by the rise of smaller personal devices, which can be mounted easily with few clips (5).

General trends indicate that **screens may be becoming less common**[7]. Now that many passengers carry their own electronic devices, fewer airlines worldwide have seatback screens.

The emergence of **BYOD (Bring your own device)** and development of novel wireless communications solutions means that the market for IFEC is predicted to grow to 10 billion dollars by 2024 from its current valuation of 5.1 billion (2018).[8] Taking out screens does make some financial sense, as carriers no longer have to buy or maintain hardware, planes can be made lighter and thus more fuel efficient and seats can be made thinner, potentially providing for additional seating.

A unique aspect of the in-flight entertainment experience, as opposed to entertainment at a cinema or theater, is the **option to opt out of viewing**. Until very recently, airplanes were closed systems that were not connected to the outside world except through radio, and so could only show content that was physically stored on board. Beginning with the widespread adoption of inflight cinema in the 1960's, airlines transmitted sound through headsets to avoid making every audience member a captive viewer of the chosen film. "This separation of sound from image runs counter to the ideal viewing situation in which the large image and synchronized sound overwhelm and envelop the spectator." [9] This trend has continued with the **increased personalization and miniaturization of the IFE experience**, facilitated by BYOD and the development of new technologies of wireless communication.[10]

WHAT IF?

What if there were other forms of entertainment available in flight?

What if there was a model of collective viewing and entertainment, similarly to watching a movie with friends.

What if in-flight entertainment didn't require headphones? Companies have begun experimenting with this idea for spacious first class seats, but further development for both business and economy seats could be done.

Jetlag

In my regular life -- the one I call "real" -- I go to sleep every night at 8:30. My body gets me up early in the morning, and by the time darkness falls I'm starting to lose consciousness, fast... In my regular life I know the time so well that I can usually tell the hour to the minute without looking at my watch.

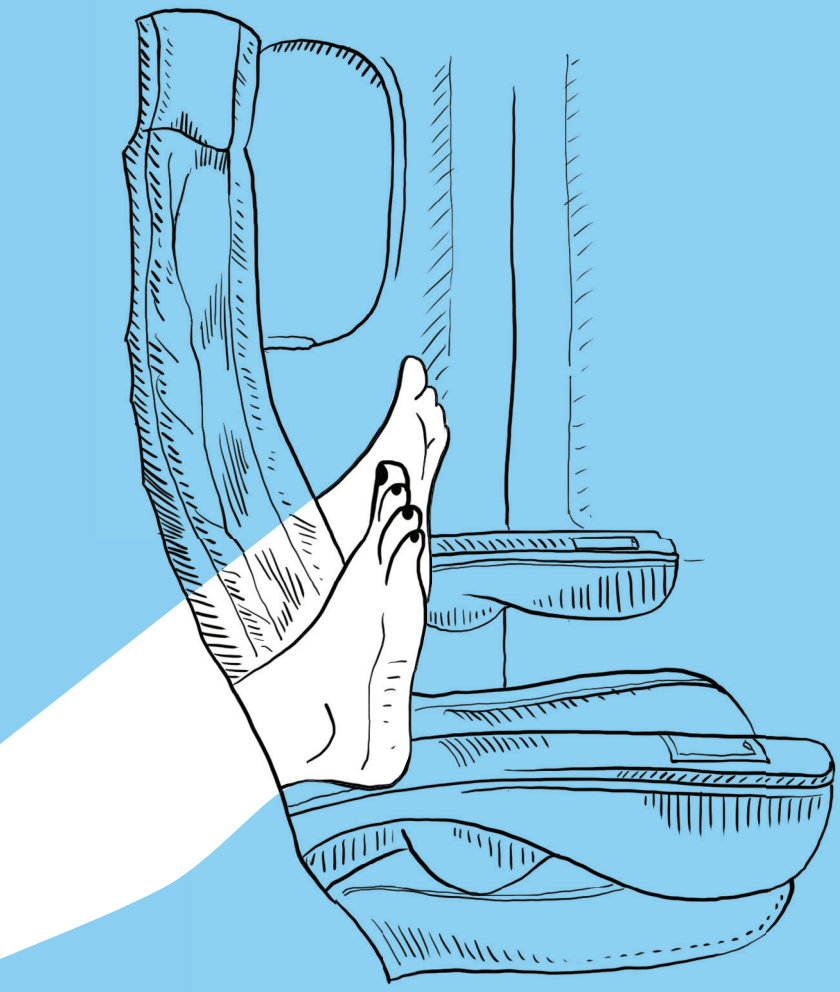
Under jet lag, however, all that is thrown into convulsions. Not just the steady routine, the sense of clear divisions, the ability to get on with the world, be in sync with it. No, something deeper is dissolved. I get off a plane, 17 hours out of joint, and tell naked secrets to a person I know I don't trust. A friend starts talking about her days -- her plans, her friends, the things she wants to do -- and tears start welling in my eyes,

I often think that I have traveled into a deeply foreign country under jet lag, somewhere more mysterious in its way than India or Morocco. A place that no human had ever been until 40 or so years ago and yet, now, a place where more and more of us spend more and more of our lives. It's not quite a dream state, but it's certainly not wakefulness, and though it seems as if we're visiting another continent, there are no maps or guidebooks to this other world. There are not even any clocks.

- Pico Iyer[1]

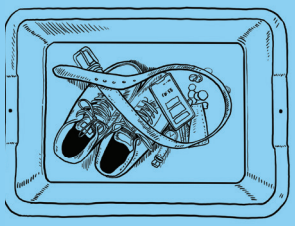
Jetiquette

A new airport culture has developed from the implicit social contract between passengers and airports.



Jetiquette operates hand-in-hand with the **implicit social contract that governs the relationship between passengers and the airport**. In exchange for security, efficiency, and access to flight technologies, passengers willingly limit one's own autonomy and even enforce these policies around them by creating unspoken rules and etiquette. Rules and norms learned at one airport may generally be transferred and applied to another one[1]. It is the nature of airports as non-places that its rules and conventions are by and large uniform all over the world, independent of its true geographical context.

1) Jetiquette in service of efficiency:
Knowing that voluntarily limiting one's autonomy will facilitate a speedier experience, one does so willingly and encourages others to do the same. Such airport etiquette include being ready to produce identification papers at security checkpoints, or wearing simple shoes that do not require much time to take off. These may cause only a few seconds of delay, but perceived ignorance of these rules can cause outsize frustration among others.[2] **Some even go so far to chastise others** for creating interruptions in the orderly process, becoming more judgmental than they would be in other contexts.



2) Jetiquette in service of maintaining personal space:
On the plane, an extensive set of norms have emerged regarding one's personal space. Personal space has been defined as "the emotionally tinged zone around the human body that people feel is their space" where individuals feel a sense of ownership and any intrusion of it leads to feelings of discomfort, stress, and avoidance.[3, 4] The variety of personal space encroachments that passengers undergo can include bodily noise, undesired conversations, undesired gaze, smells, physical contact, and physical proximity.[4] As a result, unofficial norms about whether to recline one's seat, whether to use the armrest, or whether to make conversation have developed, albeit with many exceptions and mismatched expectations.

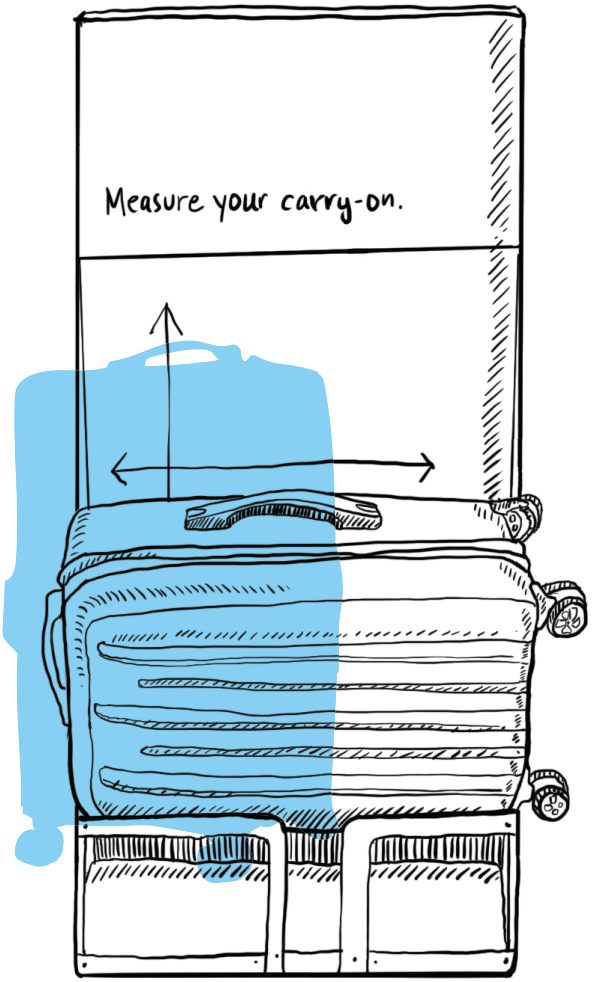
"Research commissioned by Gatwick Airport in 2017 on the likelihood of passengers bursting into tears found that 15 percent of men said that they were more likely to cry while watching a film on a plane than if they saw the same movie at home or in a cinema. The figure for women was 6 percent"[7].

These norms can be understood as **strategies to help regulate the heightened anxiety and stress** levels within ourselves and among each other. Many aspects of air travel trigger larger emotional and behavioral reactions than they would in other contexts. One explanation may be **physiological**; low cabin pressure contributes to dehydration and the reduction in the amount of oxygen carried in our blood, which can lead to fatigue, confusion, impaired decision-making, and the inability to self-regulate one's emotions.[5] Additionally, there is evidence that constant exposure to loud noises causes an accumulation of cortisol, the stress hormone, in the blood,[6] which contributes to one's inability to control one's mood, motivation, and fear. Thus the loud ambient volumes of aircraft cabin noise may also play a role.

Another factor may be **psychological** inputs, such as anxiety about flying and loss of agency. According to psychologist Jodi DeLuca, the accumulation of the pressures to keep track of time and items, as well as the perceived loss of control and the fear of a possible crash can lead a person to break down emotionally once in the air. "We have little control over our environment while we are traveling by plane. **Although we may not be consciously aware of our emotional vulnerability, our emotional brain is working overtime.**" [5] This vulnerability may manifest itself in different ways, from people confessing secrets to strangers, or developing compulsive behaviors that do not occur in other contexts. As we find it more difficult to self-regulate our own emotions, relying on these norms might be one way one tries to impose order both on oneself and others.

Luggage

The air travel system is as much about **moving luggage** as it is about **moving people**.



DESIGN DECISIONS

Luggages are primarily categorized into carry-on bags, and checked luggage. Carry-on bags refers to a type of luggage that passengers are allowed to carry with them into the passenger compartment of the plane. Checked luggage are stowed in the cargo compartment.

The physical dimensions and the weight of luggage are strictly delineated, especially regarding carry-on bags. The size and weight of carry-on bags are limited by the plane's overhead bin design, under-seat storage space, weight requirements, and financial incentives. Booking class of the passenger can also dictate the allowed number, size, and weight of the luggage, for both checked baggage and carry-on items.

The International Air Transport Association (IATA) sets guidelines for carry-on luggage size, specifying maximum length of 22 inches, width of 18 inches and depth of 10 inches.[1] However, these are not mandatory and individual airlines vary their requirements, depending on the aircraft model being used, or the booking class of the passengers. **Due to the lack of standardization, there is a large number of different size requirements among different airlines.**

Security concerns also dictate many requirements for the luggage and what can be in it. Certain types of objects can only be carried by checked luggage, while others can only be in carry-on. Liquids and gels over a certain amount, powders, sharp objects, scissors, knives, and some sporting goods must be in a checked baggage, not carry-on bags. On the other hand, airlines require that spare batteries, e-cigarettes, or powerbanks be in carry-on bags, rather than checked luggage.[1]

Despite passenger fears of losing items in the luggage, passengers are dissuaded from using locks so that it is able to be searched, and must only use specific pre-approved locks sold by the TSA.[2]

"Monitoring of our luggage at airports is probably one of the most visible methods of surveillance." [3]

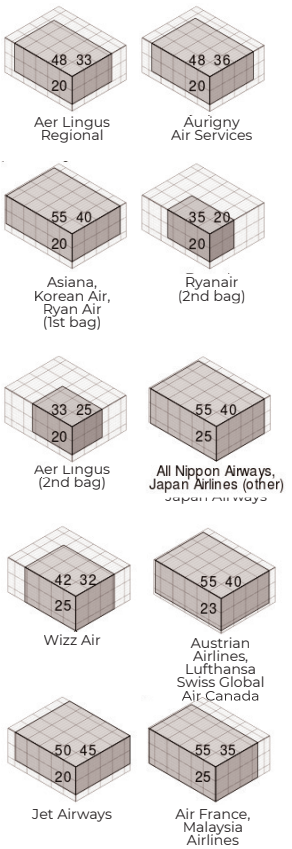


Figure 1. Carry-on bag size limiations per airline

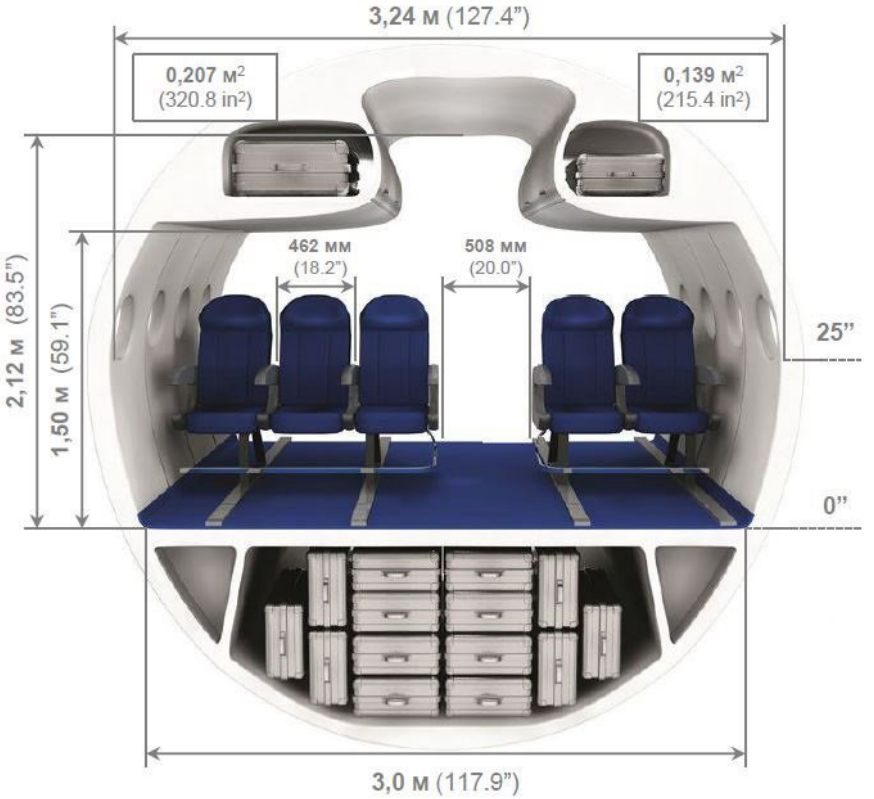


Figure 2. Cross section of an aircraft, demonstrating allocation of seats, carry-on luggage, and checked luggage

EFFECTS ON PASSENGERS

For many passengers, this **diversity of requirements can make it feel as if the size requirements are arbitrarily decided and enforced.** Ensuring that their bags are the correct weight, height, and width as the chosen airline contributes to the pre-flight stress. Because ticket prices are often tied to luggage size and type restrictions, passengers grow resentful at staff being inflexible about slightly larger or heavier luggage.

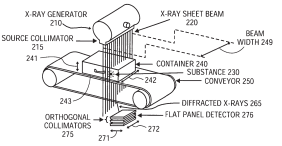


Figure 3. X-ray scanning mechanism for luggages.

Many passengers prefer to have more of their possession on hand during the flight, both to skip the time-consuming baggage check and claim process, and in fear of losing their checked baggage. This has led passengers to employ a number of strategies, such as lining up earlier to ensure that their carry-on bags do not get checked, or by paying for the right to board earlier, in order to get to the overhead bins quicker.

Additionally, it is important to recognize that the space occupied by the human body changes when accompanied by a carry-on bag. **The body bubble changes**, and activities are undertaken with only one hand free.[4, 5] This should be taken into consideration when designing the width of spaces in the airport, such as aisles in stores, size of escalators, and width of hallways.

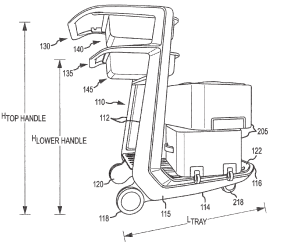


Figure 4. An example of an object that extends the body bubble.

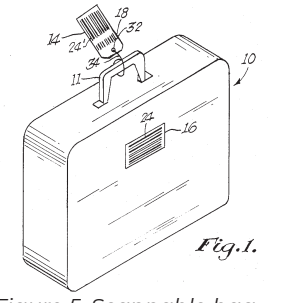


Figure 5. Scannable bag tag for checked luggages.

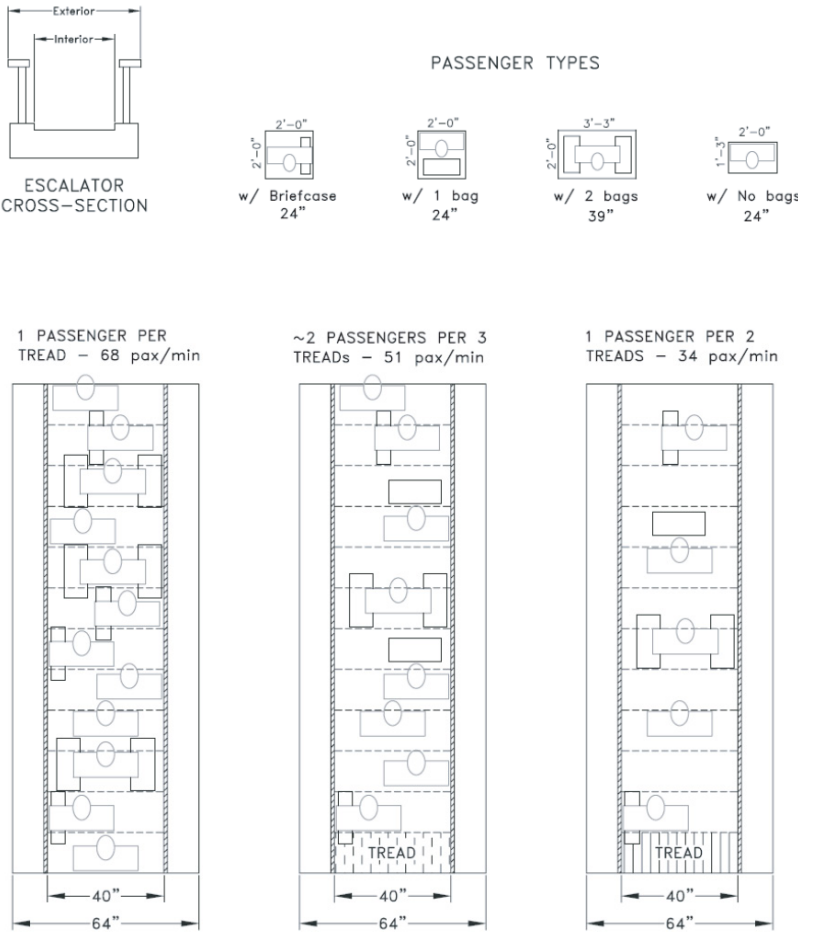


Figure 6: The design of spaces at the airport must take into account the changed body bubble of a passenger carrying luggage. Above shows a diagram of such an escalator design

WHAT IF?

What if bags were envisioned as an end-to-end experience, where bags are picked up and delivered door to door?
Through leveraging freight networks (e.g. Fedex, DHL, or Amazon fleets), a passenger's luggage could make the same journey as the passenger without the passenger needing to wait in line for the bag drop-off counter or the baggage claim in the terminal.[6] In a scenario like this, status updates of the luggage should be available to the passenger in real time to reduce traveler stress, similarly to tracking a package in the mail.

What if the luggage could move autonomously and negotiate with its immediate surroundings through sensor arrays?
Companies such as CowaRobot, ForwardX Robotics, and Piaggio Fast Forward have released designs of autonomous luggage robots that follow the owner.[7, 8, 9] These solutions might present their own challenges in that passengers may feel nervous about being out of physical contact or visual field with their belongings.

What if there was a luggage pick-up or drop off in the city center?
By having a baggage drop off in the city center, some passengers could drop off heavy luggage earlier on in their journey to the airport. This would allow passengers relief from carrying heavy items, and the passenger would not need to wait in long lines for the bag drop-off counter or the baggage claim in the terminal.

How can we discourage passengers from retrieving their carry-on luggage during emergency evacuations?
During accidents, studies have also found that passengers often pause to retrieve cabin baggage during emergency evacuations despite instructions to the contrary, raising questions as to whether this contributes to the loss of life[10]. Remote locking of overhead baggage bins is being considered as a possible solution, but this may have unintended consequences. Striking the right balance of tone, severity of technology, and execution will be important.

Benefitsof end-to-end luggage system Include:

- Quicker aircraft turnarounds

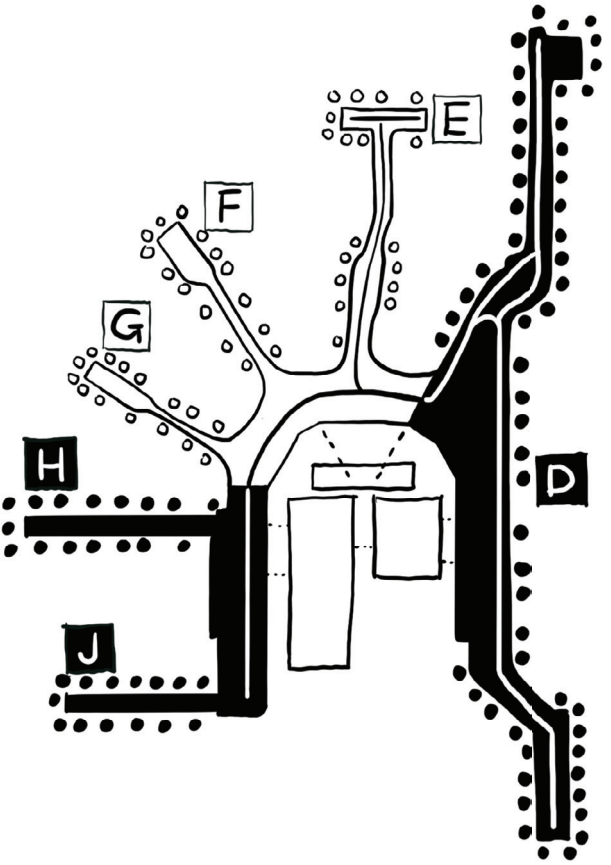
- Smaller terminal building footprint and capital costs

- Airlines benefit from reduced aircraft payloads or available hold capacity.

- Airport check-in timings are no longer reliant upon bag delivery to the airport[4].

Map

"What the passenger needs, in the course of his movements within the terminal premises, is a correct sense of direction"



DESIGN DECISIONS

In his seminal 1960 text The Vision of the City, Kevin Lynch defines wayfinding as "consistent use and organisation of sensory cues from the external environment in order to reach a desired destination."[2] **Effective wayfinding results from a successful interplay between human factors and environmental conditions**. Human factors include an individual's aptitude for cognitive mapping and spatial orientation, while environmental factors include paths, landmarks, layout complexity and visual aids.[3] **After signs, maps are the most common visual communication aids deployed in airports.**

Are there shapes, forms, or arrangements of space that are inherently easier or more pleasurable to navigate?

Studies have shown that people are not always equipped with the tools to navigate 3D space from 2D drawings, or understand directional arrows.

Despite the popularity of maps as wayfinding devices, there is little published research devoted to the theory of map design. Maps can take many different forms, such as plans, views, fantasy drawings, You Are Here (YAH) maps or a combination of types.[4] YAH maps are presented in two primary ways - those requiring metal rotation and those that are pre-aligned to an assumed orientation of the viewer.

Recently, companies such as TripIt have developed interactive airport maps that can be navigated via an app on one's phone.[5] The promise of this sort of personalized navigation is the removal of the uncertainty associated with conventional maps.

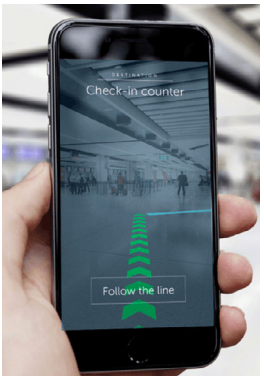


Figure 1. TripIt provides interactive airport maps as an app on one's phone.

EFFECTS ON PASSENGERS

Research has established quantitative methods for evaluating how easily a person can navigate a particular space, through sight line analysis. It is based on the premise that orientation is a function of the visibility of a destination (ie. sight lines).[6] More recent approaches employ Bayesian networks to integrate analysis to demonstrate that **"spatial anxiety" has the largest impact on a passengers ability to successfully navigate an airport.**

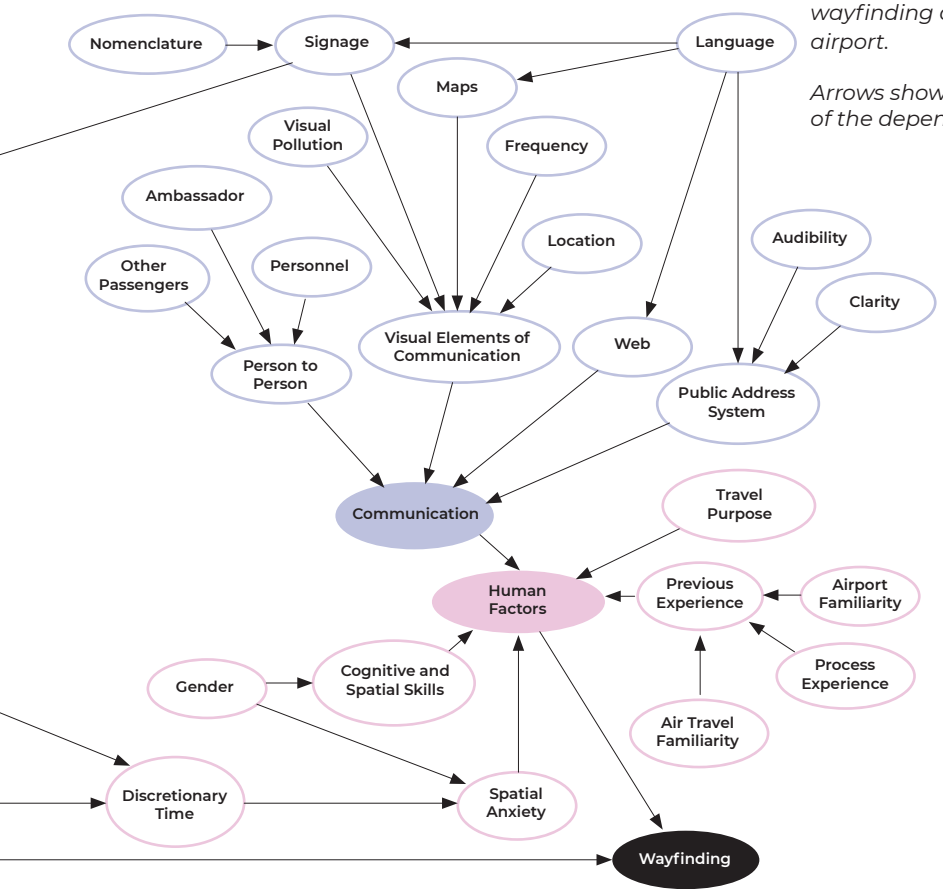
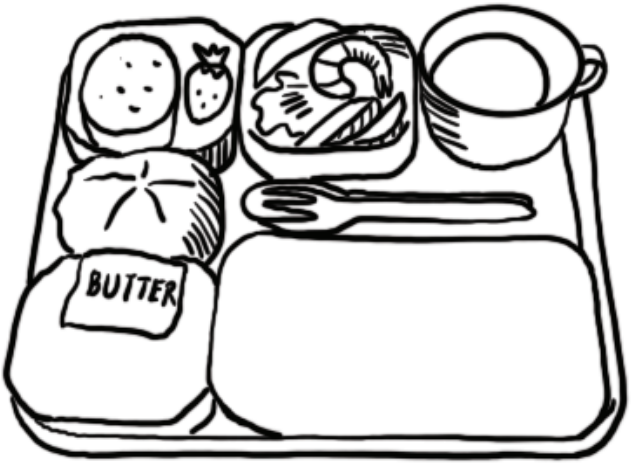


Figure 2: A Wayfinding Bayesian Network diagram,[7] showing the human and environmental factors that impact one's wayfinding abilities in the airport.

Arrows show the direction of the dependencies.

Meal Tray

The average airline passenger leaves behind around 3 pounds of garbage per flight, and a substantial portion of that comes from the packaging of in-flight meals.



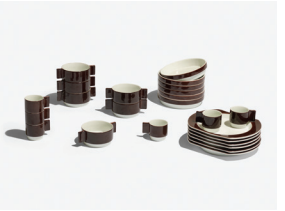
DESIGN DECISIONS

In the early days of in-flight catering, it was typical for airline meals to be served on the passenger's lap, atop a pillow. After initial experimentation with pillows, covers that transformed into pedestals, and folding tables that were inserted into armrests during meal times, the integrated tray tables on seatbacks became the industry standard by the mid-1950s.[1] Since then, the design and dimensions of the seatback tray table have strongly determined the design of the meal tray, leaving little room for either to maneuver.

Airlines commissioned a number of notable product designers to take on the in-flight tableware as a challenge, including Robin Day, who would write in 1968:

> *"This was an interesting exercise in logistics... as the economy of space and weight in even the smallest things are crucial to the economics of operating passenger aircraft. Relationships of dimensions and stacking were essential on several levels: first the compact fitting of vessels and implement of trays; secondly the exact accommodation of trays on mobile trolleys; and thirdly, the accommodation of this equipment on the galley, on the airfield and in the airport."* [2]

In addition to the modular aspects of the design, the tray has to meet strict material specifications as well. It must be heat and cold resistant, to withstand the hot temperature during the cooking and sterilization, and cold temperatures during storage. It also needs to resist scratching from utensils and chemicals used in regular cleaning. Finally, it needs to withstand the movements of being in the air without shifting and spilling its contents.



Figures 1, 2, 3. Meal tray designs, taking into account modularity and stability

EFFECTS ON PASSENGERS

One of the earliest designs of airplane meal trays was developed in 1937 through the collaboration of Don Magarrell, a hotel manager hired by United Airlines, and Industrial Designers Inc., a product design atelier.[3] **This design set the standard for our current three-course meal and the corresponding meal tray** on the plane, consisting of depressions for appetizers, main dish, and dessert. The economy class meal tray has not changed much from that in the last eight decades, keeping the three-course meal as standard. Only in the last few years have airlines begun to vary from the three-course meal, partially in response to growing pressures about the amount of food waste generated by each flight.

With increasing attention given to the environmental impact of air travel, **passengers have begun to question what happens to the meal tray, packaging, and leftover food after the meal.** The average airline passenger leaves behind around three pounds of garbage per flight,[4] and a substantial portion of that comes from the packaging of in-flight meals. In 2017 alone, it was estimated that the airline industry produced up to 5.7 million tons of cabin waste, over 20% of which was untouched food and drinks.[5] In addition, most of the resulting waste cannot be recycled or reused due to differing international regulations and concerns about biosecurity or the spread of diseases. Rethinking food presentation and packaging will be critical to addressing the growing sustainability concerns about air travel.

WHAT IF?

What if airlines rethought the form of the three-course meal tray?

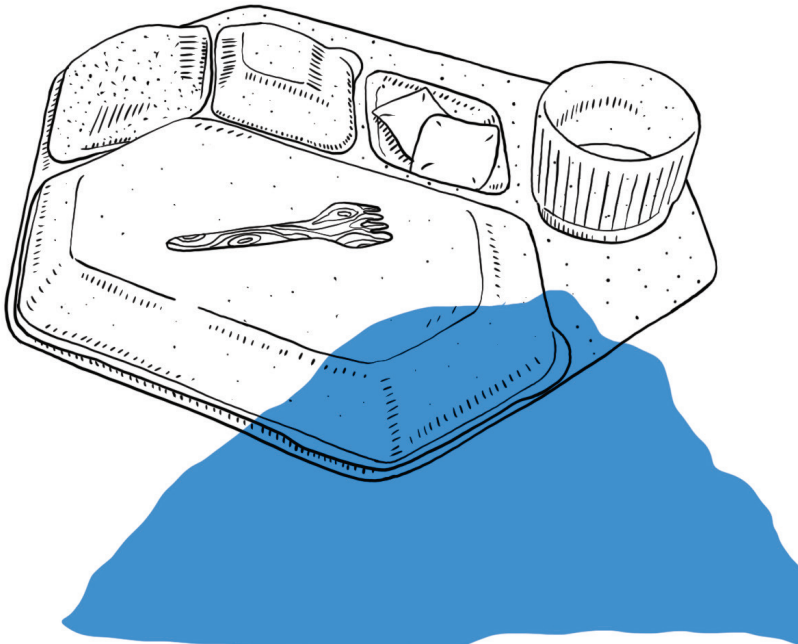
Qantas Airlines has been a leader in the industry in the effort to reduce airline waste,[4] pledging "to eliminate 100 million pieces of single-use plastic from flights by the end of 2021 [...and] reduce its waste by a whopping 75 per cent." [7] As part of this effort, Qantas has been rethinking the meal tray altogether. Instead of the standard design of the three-course tray, with allocated spaces for appetizers, main course, and dessert, the airline ditched the tray altogether and uses a single "serving plate" for the main course. While serving the meals, flight attendants also offer a warmed, pre-buttered bread, as well as dessert in a disposable pot. This allows passengers to refuse these extra items if they wish, which allows these items to be donated rather than thrown away.[8]

Figure 4. Qantas Airlines one-course not three-course meal presentation

What if the meal trays were compostable?

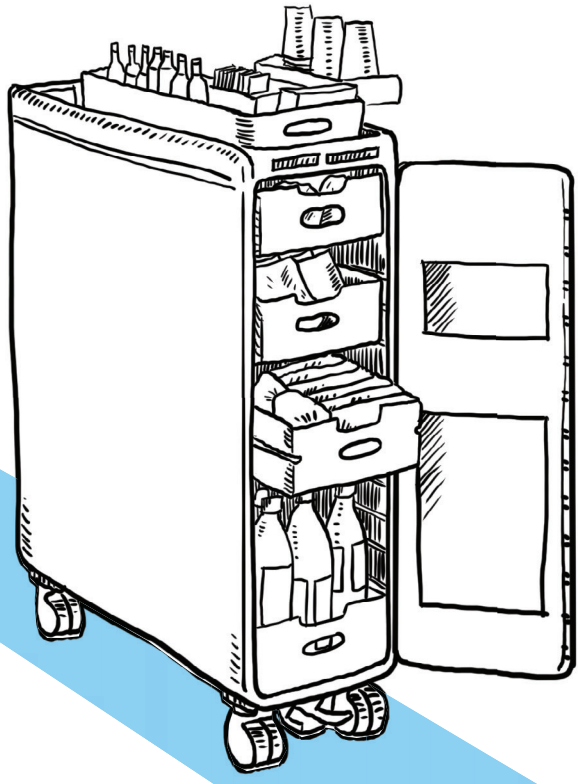
The air travel experience design consultancy PriestmanGoode redesigned the dining trays out of processed coffee grounds and husks and made them compostable, while preserving the plastic appearance of trays with which passengers are familiar. "If you picked it up, you wouldn't know it wasn't plastic," Jo Rowan, the associate strategy director of the firm, stated in an interview.[6]

Figure 5. PriestmanGoode compostable tray



Meal Trolley

Meal trolleys are the most passenger-facing component of the galley. Their design must take into account not only the aisle width but also other galley parts and flight crew coordination.



DESIGN DECISIONS

A meal trolley, also called *galley trolley* or *service trolley*, is a wheeled cart used by flight attendants to deliver meals, beverages, or other service items to the seated passengers. It is typically a rigid metal box with castering wheels, doors, and handles, and is stored in the aircraft galleys to be occasionally brought out to the aisles during service time.

Figure 1: Typical Trolley Dimensions

There are currently only three main design families of service trolleys in use.[1, 2] One reason for this low number of variations is that the trolley is typically designed as part of a kitchen galley set. Service trolleys can be thought of as **the most passenger-facing component of the galley,** which also includes ovens, fridges, freezers, waste compartments, and other miscellaneous stowage. The intense pressure to maximize space on the aircraft can be easily observed in the puzzle-like combinatorial nature of the galley parts design.[3] The design of the service trolley, therefore, is affected not only by the cabin aisle width, but also by the desire to standardize its form with the other galley stowage compartments

Figure 2: Meals served buffet style (1950s)

Meal trolleys on the aircraft have a longer history than the typical **rigid metal box** of today. Before the standardization of galleys, meals were transported to passengers by **hand**, by portable folding **trays**, or on large **buffet-style tables** served by attendants. As the 1960s ushered in a generation of larger widebody airplanes, meals could no longer be efficiently delivered by hand and thus the service trolley system was launched.

As with most cabin interior components, materials used for service trolleys must prioritize abrasion resistance, allowing it to be used and cleaned repeatedly, with high tensile and impact strength even in the dry state and at low temperatures.[4] To account for the effects of turbulence, wheels are equipped with braking pedals, and doors are lockable so that the contents do not spill out.

EFFECTS ON PASSENGERS

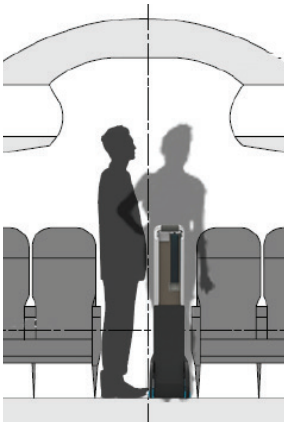
One psychological effect of the service trolley is that it exacerbates the **feeling of being trapped** in confined spaces. Its presence nullifies the possibility of leaving the seat for a stretch or usage of the bathroom. This congestion in the aisle frequently causes a line of trapped passengers seeking to return to their seats.[2, 5]

The meal trolley should also be considered in the context of its social role as an unintended instigator for interaction. **The in-flight meal service provides a rare interruption** to the uniformity of the passenger experience between take-off and landing. For many travellers, the brief exchange of words with the flight attendant - coke, please - might be the only social interaction that they have with another person during flight. A less welcome interaction might be the flight attendant awakening a sleeping passenger to ask whether they would like a meal. Moreover, the meal service is one of the only communal experiences that take place on the plane, where all passengers engage in the same activity even if without actively engaging with each other.

Any consideration of the design of the meal tolley must keep in mind that the physical design of the service trolley is inevitably entangled with the systems level design of food delivery and waste collection.[6] This in turn, affects the required number of flight attendants per aircraft, as they are integral to the timing of food delivery and waste collection during flight.[2] **Changes to the design of the meal trolley will have repercussions on the number of flight attendants needed per flight,** which will most likely have larger implications for the overall passenger experience.

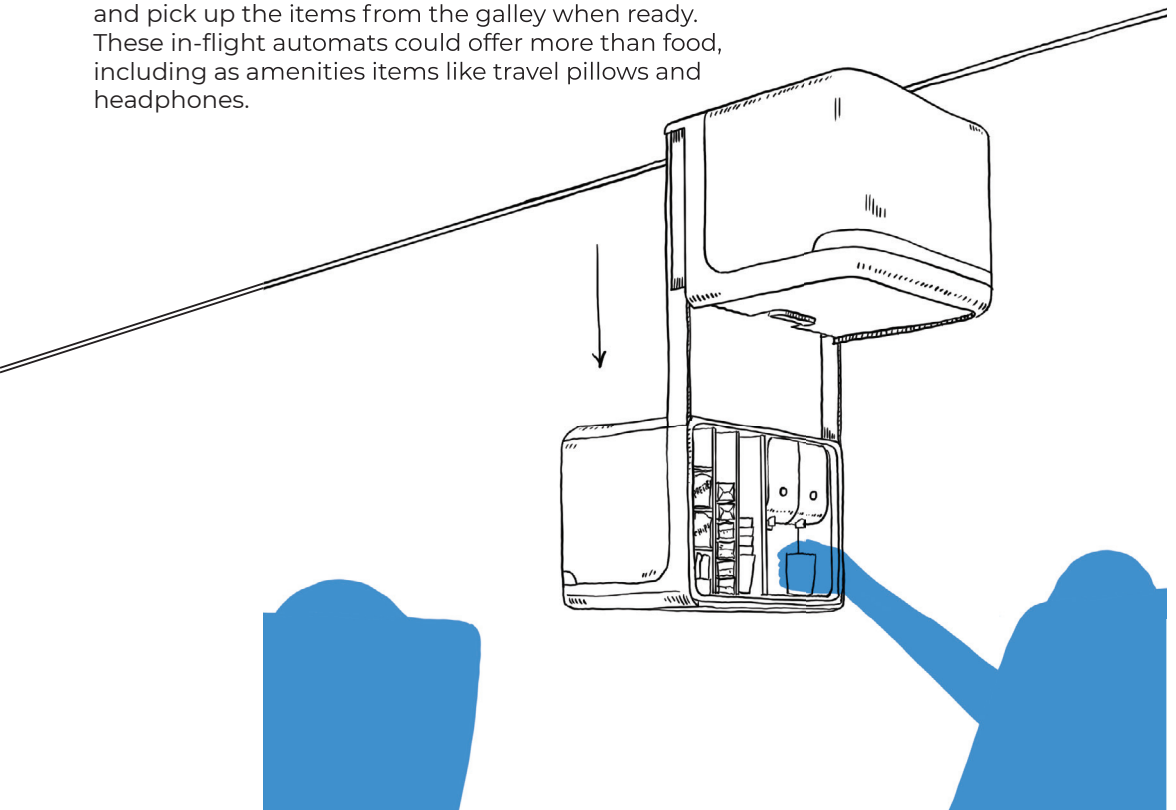
WHAT IF?

What if there was a way to avoid congestion in the aisles due to trolleys?
Meal trolleys, accompanied by one or two flight attendants, frequently create congestion in the aisles. A line is frequently formed behind the trolleys as passengers seek to go to or return from the lavatory. One design strategy is to use half-width trolleys, where passengers can sidle past.[7] Another design strategy is to transport food on a railing system above the aisle.[8, 9] This solves both the issue of passengers passing by, and also the common complaint among flight attendants that repetitive crouching movements to retrieve meals cause joint pains.



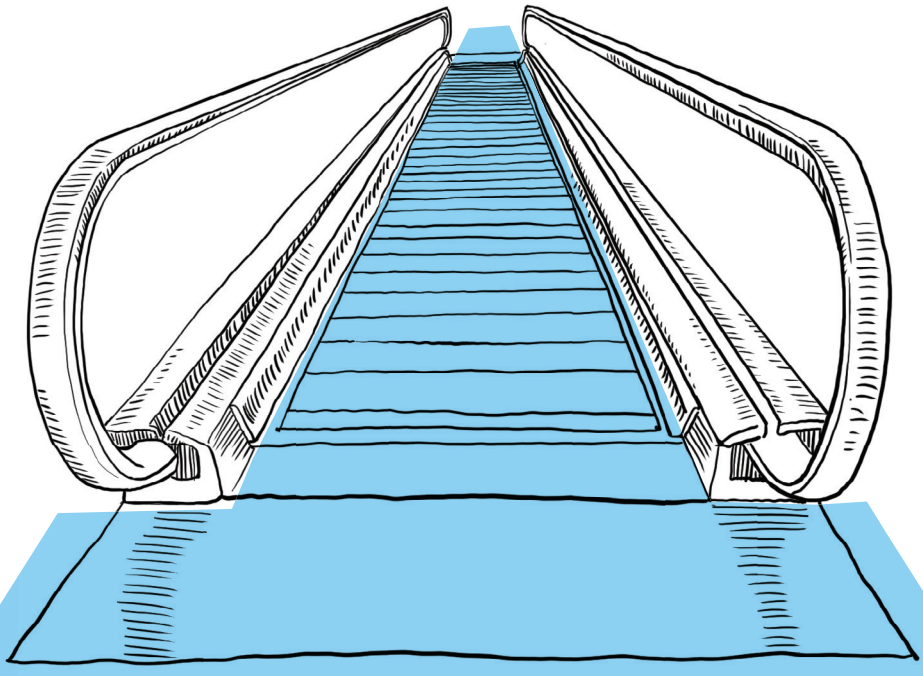
Figures 3, 4: Methods to avoid congestion of aisles due to trolleys

What if the meal delivery process was automated?
As a temporary measure in light of Covid-19, several carriers are forgoing meal services or providing only pre-packaged snacks. Instead, the traditional meal and trolley service could be replaced by an automat, or a vending machine style of ordering.[10] This would require a rethinking of the kitchen galley entirely. Passengers could select from the menu on an app, and pick up the items from the galley when ready. These in-flight automats could offer more than food, including as amenities items like travel pillows and headphones.



Moving Walkway

Travelators are a particularly effective tactic of **guiding passenger movement**, and achieving directional crowd control.



DESIGN DECISIONS

A moving walkway, also known as a travelator, is **a moving conveyor belt system that transports people** across a horizontal or inclined plane over a distance. They are usually installed in pairs, one for each direction, and commonly 3 to 4 feet wide to accommodate either a person with luggage, or two people standing side by side. These moving walkways are common in passageways between concourses and the terminal, and especially long concourses.

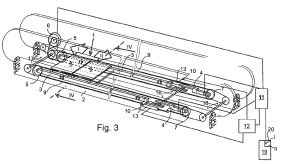


Figure 1. Travelator and method for controlling the operation

Most airports today use walkways that move at a slower speed than a natural walking pace, so **using the walkways only minimally expedites travel times.** These moving walkways travel at about half the speed (1.4 mph) of a natural walking pace (3 mph). Studies have calculated that passengers on walkways move on average at a **speed of 3.66 mph**, only nominally faster than the normal walk speed at an airport of 3 mph.[1, 2]

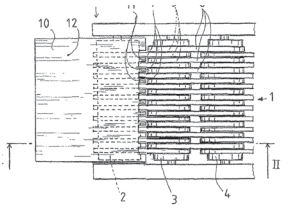


Figure 2. Comb system for acceleration and deceleration of passengers

Moving walkways have changed very little in the last 100 years, but there have been a few high-profile attempts at developing high-speed walkways in both airports and other public urban settings, to varying success. In 2002, CNIM installed the experimental 607 ft high-speed moving walkway in a metro station in France, which operated at a speed of 7.5 mph at first, and later was reduced to 5.6 mph due to safety concerns. It required a 33-feet long acceleration zone, and many users lost their balance. Eventually, it was abandoned in 2009[3]. In 2007, ThyssenKrupp installed two high-speed walkways in Toronto Pearson Airport, which operates at an initial speed of 1.2 mph, speeds up to 4.3 mph, and slows back down to 1.2 mph.[4] It uses a pallet-type design which accelerates and decelerates users more naturally and mitigates many of the issues raised by CNIM's earlier version.

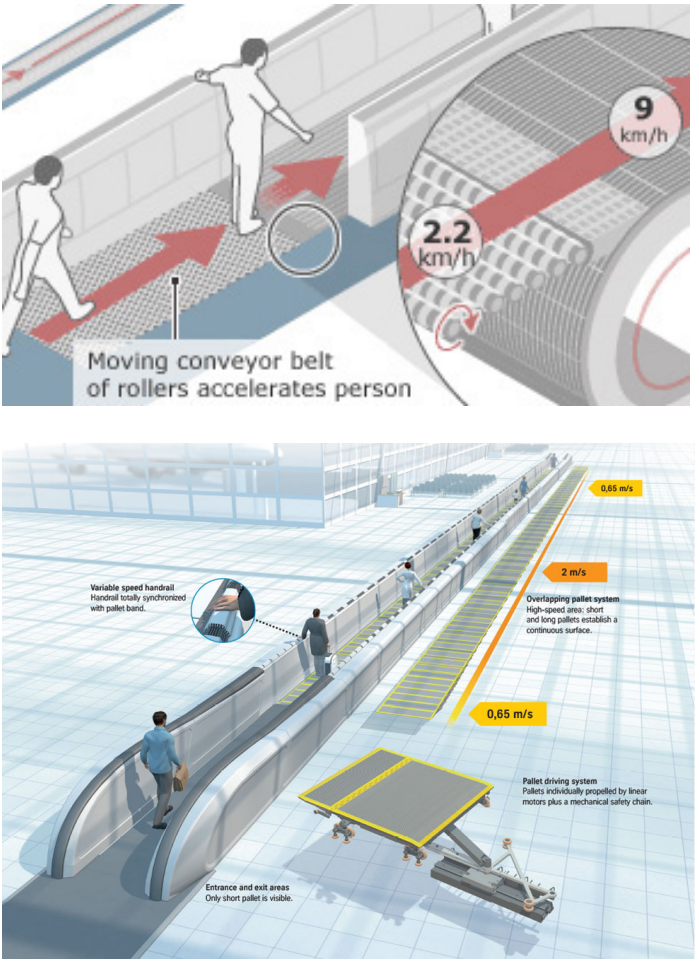


Figure 3 and 4. Diagrams of CNIM's high speed travelator (above) and of ThyssenKrupp's high-speed travelator (below)

EFFECTS ON PASSENGERS

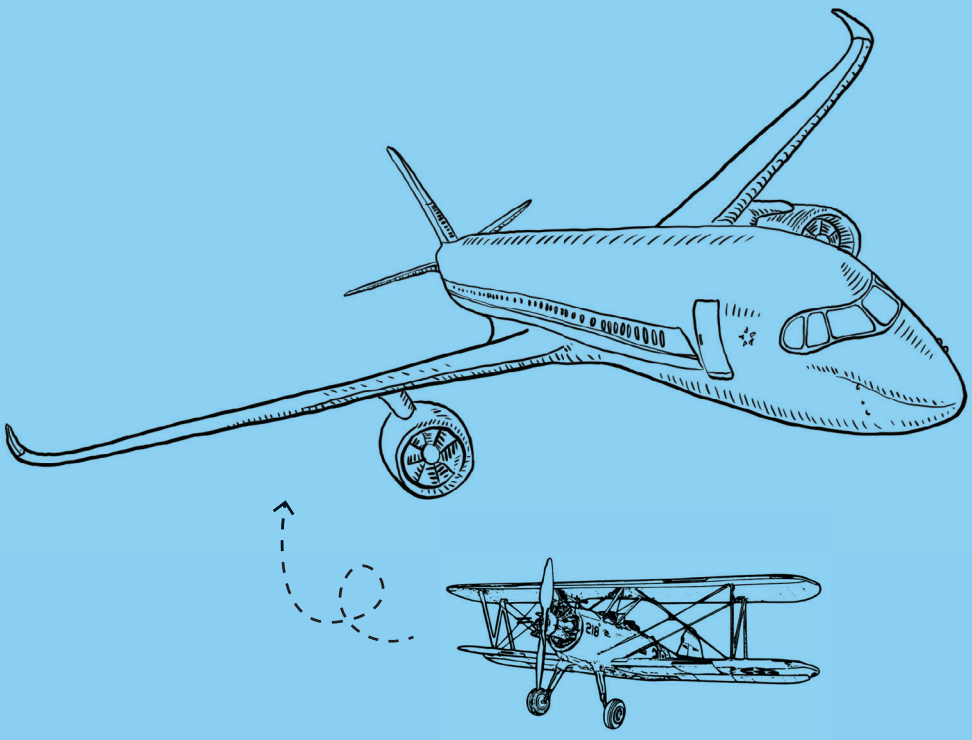
As many large airports undergo renovations in recent years, airport designers have been deliberating whether to keep or remove moving walkways.[5] One argument for removing them is that the walkways do not significantly increase speed for the passengers, and that they take up valuable space that could be used for retail and food stores and generate further revenue.

However, moving walkways generally remain **popular** among passengers. For most, moving walkways invoke delight as **passengers can stand still and allow the walkway to transport them with no effort**. As most passengers travel with heavy luggage in tow, moving walkways can also provide a brief respite, and they are especially a boon for elderly travelers with reduced mobility.

For airports, these walkways are **an effective strategy of directional crowd control**.[6] It prevents congestations and gridlocks in busy passageways because it keeps passengers moving in one direction, and provides a mental and visual separation of sides of the corridor as the “fast lane” and a “slow lane”.

Mythologizing

From tales of near-disasters to gripes about endless delays, dramatic weather shifts, and lost bags, airport horror stories often take on a life of their own.



From tales of near-disasters to gripes about endless delays, dramatic weather shifts, and lost bags, **airport horror stories often take on a life of their own**. Much more than any other hubs of transportation, **airports loom larger than life in the cultural imagination**. These stories become familiar accounts of a place that seems to recycle and thrive on its own mythologies.

It may be that mythologizing is a way for today's passengers to reconcile the realities and banalities of air travel today with both the supposed glamour of air travel in the past and the inherent allure of the idea of flying. Despite the bodily discomforts inherent to the early flights, popular conception about the glamor of past air travel has endured. Additionally, yearning for flight is a familiar, universal human longing, but people have come to recognize that the air travel experience as it exists today cannot help them satisfy the childhood dreams of flying.

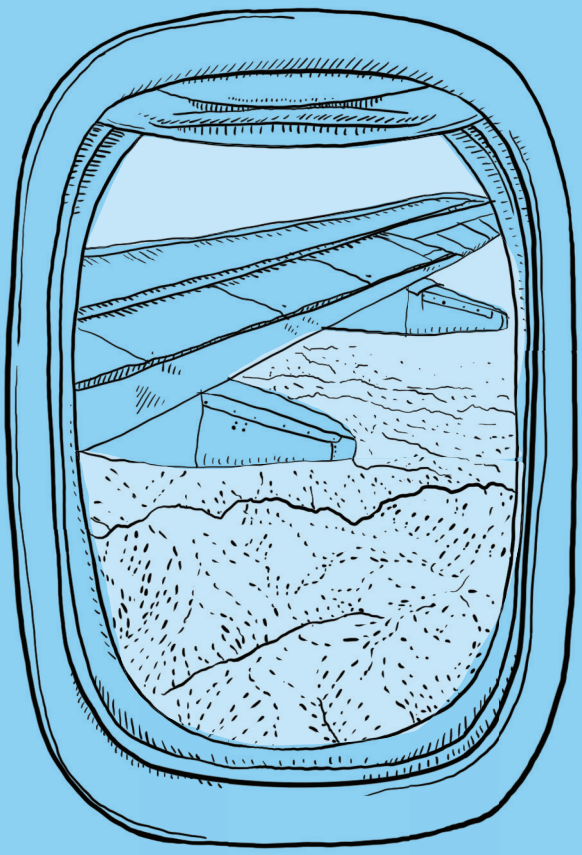
"I was as free as a bird... Incredible! It's beautiful. You're breaking the bounds of gravity. I have a feeling this is the innate desire of man." [1] Skating on ice on a cold, clear, and crisp afternoon after a long hiatus, the hockey player Eric Nesterinko remarked those words describing his joy of movement on ice by using words analogous to flying. Flying, then, should naturally be even better, even more freeing, and even more incredible. The reality of flying today's is that the passengers do not get to experience many sensations of freedom.

Yi-Fu Tuan further captures this contradiction between romantic notions of flying with the realities of air travel experience in the following passage:

> *Small aircrafts of the kind in use during the 1920s are capable of extending man's freedom, his space, as well as putting the human being into a more intimate relationship with the vastness of nature... When transportation is a passive experience, however, conquest of space can mean its diminishment. Think of the jetliner. It crosses the continent in a few hours, yet its passengers' experience of speed and space is probably less vivid than that of a motorcyclist roaring down a freeway. Passengers have no control over the machine and cannot feel it as an extension of their organic powers.* ***Passengers are luxury crates****--safely belted in their seats--****being transported passively*** *from point to point."* [2]

Air travel, which seems to promise such freedom, is a fundamentally different experience than expected. To some degree, this is unavoidable in order to be able to transport the mass quantities of people in a safe and efficient manner. As a result, every anecdotal account from friends of friends becomes entrenched in the cultural understanding of air travel, and society becomes transfixed by every accident or crash in the news.

These stories we hear or recount vividly to ourselves have the power to shape our perspective about the entire air travel journey; "changes in perception and attitude can seem to alter an environment more markedly than if it had been physically changed." [2] In designing airport spaces and the air travel experience, **designers and architects must take into account this "feedback loop where stories shape airports, and airport shape stories** - the dynamic coshaping that exists in the everyday practices of air travel." [3]



Non-Place

In the social sciences, the airport is usually analyzed as a Non-Place, a space of transience where large numbers of people pass through anonymously.

In his 1995 book *Non-Places: An Introduction to Supermodernity*, French anthropologist Marc Augé deploys the term '**non-place**' to describe generic spaces such as airports, train stations, highways, hospitals, and malls, which, however elaborate and grandiose, do not confer a feeling of place[1]. This analysis **set the foundation for all following analysis of the airport** in the social sciences, a testament to the significance of it as a framework to understand the social and spatial dynamics at work at the airport.

"What is a place for some may be a non-place for others, and vice versa. An airport, for example, does not have the same status in the eyes of the passenger who hastily crosses through it and an employee who works there everyday."

What is a non-place? Non-places are spaces of transience where large numbers of people pass through as anonymous individuals, but do not relate to or identify with the space in any intimate sense. These are defined in opposition to 'places', such as homes, cafes, and vibrant parks, which are "relational, historical, and concerned with identity." [2] Places are sites of organic social relations that contribute to the nurturing of one's identity. **Non-places are sites where social action does not take place, and poetics of dwelling do not thrive.** Residues from human practices do not accumulate as they are continuously wiped out of existence.[3] Instead of creating a sense of community through shared experiences, non-places inadvertently hold people apart from each other, creating a feeling of "solitary individuality" among the masses.[4]

The airport is an especially potent example of a non-place, conforming to all of the following key attributes of non-places:

1) Non-places are spaces of transience where large numbers of people pass through anonymously. They tend to be large-scale public institutions, with constant flows of a large and diverse mix of people. Here, markers of one's identity serve to prove one's instrumental identity, not social identity. At the entrance of the airport, one's identity is checked, passport stamped, and boarding passes printed. These documents may include detailed identifying features, but these markers affirm only an instrumental identity - one required to keep on moving or to keep on shopping.[5]

2) Non-places enforce continual movement and directionality. In non-places, one is only allowed to follow certain paths; one's movement, gestures and

bodily acts are being guided. The design of these architectural spaces must mediate and control the human interactions taking place, in order to help usher the sheer numbers of people through with minimal friction.

3) Operations behind-the-scenes are very opaque to the average public. And by extension, the average user or passenger is expected to forfeit a large degree of one's autonomy in exchange for access to the flight technologies in the most expedient manner. One must trust that the monitoring and cleaning of airplane parts, safety features of the plane, baggage retrieval system, surveillance monitors, gate assignment system, and so much more are all in order without being able to confirm for oneself, and without having the know-how to judge correctly. This trust in anonymous and technological complex systems is a general feature of Modernity as observed in social analysis literature, but is made extreme in the case of air travel because the consequences of failure are so high.[6]

4) Surveillance and sorting techniques are fundamental to the operation of most non-places. Whereas most users of non-places are expected to place a significant amount of trust in airport operations, the same cannot be said for the reverse. "Non-places are replete with the most up to date surveillance technologies to 'find' and sort the population into various categories: consumer, citizen, terrorist, and frequent flyer to name a few." [5] Many surveillance techniques are deployed in service of preventing potential terrorist attacks, while many sorting techniques are deployed in service of improving efficiency. The line between the two is often blurred, provoking privacy advocates to lament the increasing ways personal information is captured and processed.

5) Non-places tend to look homogeneous, regardless of true geographical context. Most people agree that a layover at a city's airport does not permit one to claim that they've visited the city. Airports often feel remarkably similar to one another, and indeed, function most efficiently when the passengers need not confront the challenge of otherness—unique places, politics, and personalities. Even "momentary explosions of difference", such as when an inbound

plane unloads hundreds of passengers from a particular country, quickly becomes homogenized as the passengers mix with the hundreds of others in the passageways of the airport.[7]

There are practical reasons that spaces in the airport must be repetitive and modular; as airlines emerge, merge, and collapse, gates and terminals must be adaptable to change. However, that alone does not explain the generic feeling inherent to non-places. Because they are not places of organic social interaction, where local referents and human practices accumulate, non-places have a difficulty becoming imbued with social meaning. “Sterile is a word often used to describe non-places, in contrast to thick contexts of ordinary life.” [6]

Lastly, it is important to note that non-places do not exist in pure form; places may reconstitute themselves in it, and meaningful social relations can take place here and there. An airport, for example, may be non-place for most passengers, but a place for an employee who works there everyday; shopping malls may be non-place for a shopper conducting anonymous transactions with store clerks, but a place for teenagers to gather and strengthen social connections.

> *“Place and non-place are rather like opposed polarities: the first is never completely erased, the second never totally completed; they are like palimpsests on which the scrambled game of identity and relationships is ceaselessly rewritten.”* [2]

P.A. Announcement

Public address announcements can contribute to the acoustical pollution of the airport.

DESIGN DECISIONS

Airports use the public address (PA) system announcements to inform passengers about service status updates, ground transportation options, on-going construction efforts, calls for boarding, delays, and emergencies. A number of factors contribute to the voice, timing, volume, message format, and repetition of announcements in the airport.

First, most airports around the world use standardized announcements from a select few companies which provide the voice recordings for paging systems. As a result, **most English announcements at airports worldwide share the same voices** - that of either Carolyn Hopkins or Jack Fox. Their voices can be heard at more than 200 airports, including John F. Kennedy Airport, Incheon International Airport, and Charles de Gaulle Airport.[1, 2]

Second, the **timing of call-to-gate announcements are determined by an agreement** between the airlines and the airport. Airlines and airports agree on gate announcement rules in advance to ensure that announcements are not exploited in favor of either party. If the announcements are made too early, there is a negative impact on airport operators' retail revenue, as the passengers are guided to the gate lounge away from retail. However, if the announcements are made too late, there can be a negative impact on ensuring that passengers are boarded in time, leading to flight delays.[3]

Thirdly, characteristics such as the **volume, message format, and the repetition of announcements are standardized**, following recommendations by bodies such as the National Academy of Engineering[4]. These recommendations can be as specific as dictating the order of information conveyed, or the length of a pause between repetitions. These guidelines include explanations for these recommendations, such as

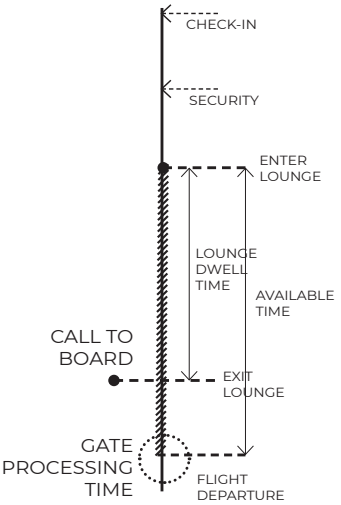
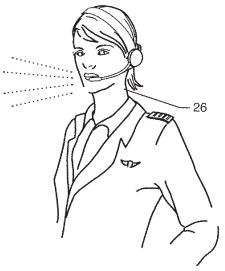


Figure 1. Timing of the call-to-gate PA announcement[3]



"Repeating a message after a very short delay allows time for non-native listeners to process what they are hearing and understand its meaning. The delay must be brief: if the delay between the original and the repeated message is too long, passengers may have returned to conversations, phones, tablets, or other distractions and fail to catch the entire message again." [4]

EFFECTS ON PASSENGERS

"When passengers were surveyed at a busy airport check-in area, they were often found to be genuinely unaware that any PA messages had been played in the preceding 10 minutes"[4].

In the myriad of acoustical distractions that characterize the airport experience, PA announcements are being drowned out by the roar of jet engines, beeping of machines, door alarms, and other background noise. **It is difficult to get passengers to listen to, or to comprehend announcements in an airport setting.**

First, the **acoustic properties of the spaces** themselves are not conducive to reflecting clear and intelligible sound. The terminals tend to be large halls with high ceilings, many hard surfaces, and lengths often greater than five times the width, contributing to noticeable echoes and distorted sounds.[4] These challenges of room dimensions, material properties, and other spatial components of the airport are compounded by other background noise - of people talking, TV screens, HVAC systems, and escalators.[5]

Secondly, there are also **human factors and behavioral tendencies** to take into consideration. Studies that showed that both experienced and first-time fliers were unlikely to pay much attention to auditory messages[4]. The aural bombardment led passengers to tune out many of the announcements.

Acoustical pollution at airports is an issue that goes beyond garbled messages and inattentive passengers. There have been several **instances of panic caused by incidents of loud noises** inside the terminal. For example, in August 2016, two different U.S. airports experienced two separate incidents of panic and evacuations, where people believed that guns had been fired or bombs had been found.[6]

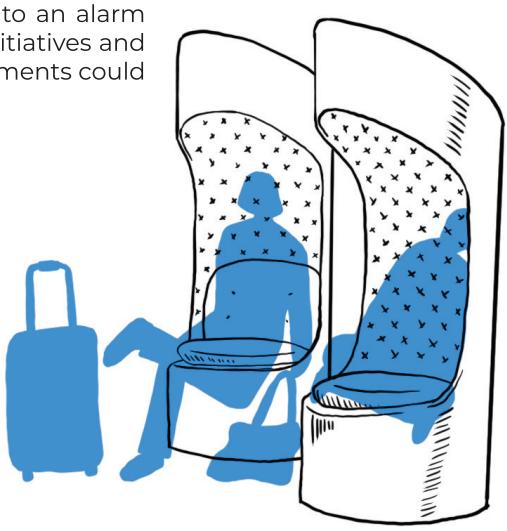
WHAT IF?

What if airports adopted a "silent airport policy"?
A number of airports such as the London City Airport, Helsinki Airport, and Barcelona El Prat, has adopted the "silent airport policy", where PA announcements in most spaces of the airport are made only for emergencies, lost children, and flight delays, and announcements for flights are made only in their specific boarding gate areas.[5] This effort intends to help reduce noise pollution throughout the airport.

What if airports provided quiet rooms to offer a sensory respite?
Airports could offer respite in designated areas from the sensory bombardment of the rest of the airport. Pittsburgh International Airport recently opened a suite of "sensory rooms" inside its airside terminal to help travelers on the autism spectrum decompress from the stress of flying.[7] These rooms can be adapted for each user's preferred sound and light levels.

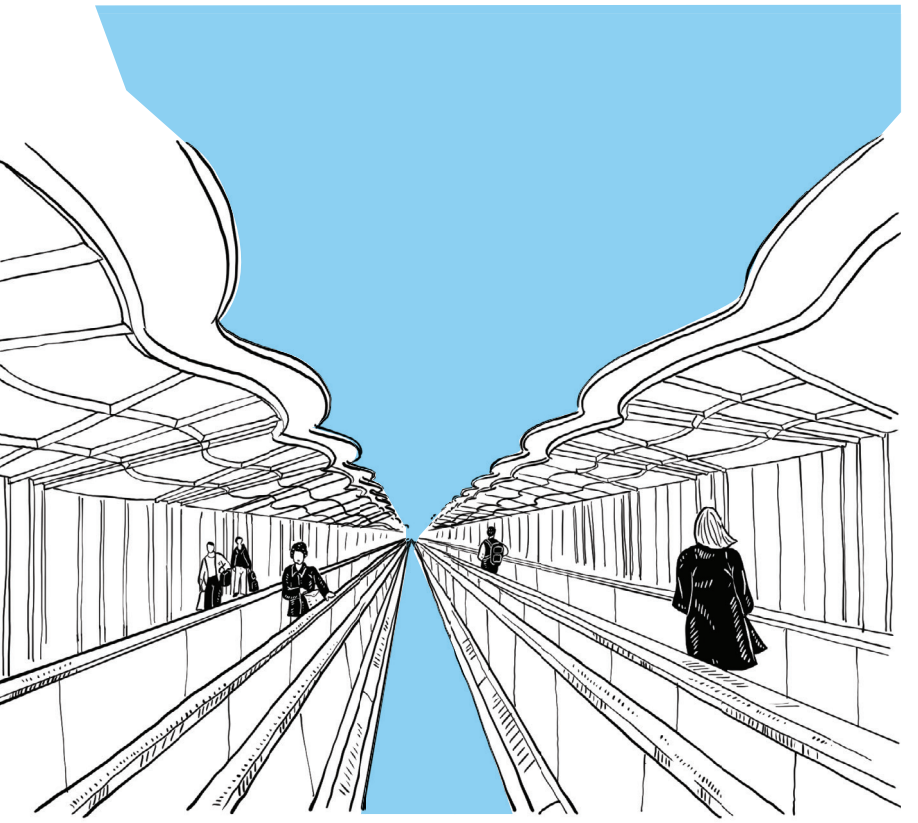
What if airports learned from the hospital industry's efforts to improve their sonic landscape?
The movement to change the sonic landscape at hospitals can serve as an inspiration for airports; device manufacturers in both airports and hospitals are led to err on the side of making alarms more startling, because of liability concerns for giving insufficient warning.[8] However, this has contributed to an alarm fatigue and acoustical burnout. Similar initiatives and assessments of airport acoustical environments could take place.

Figure 4. Furniture at the sensory rooms at Pittsburgh International Airport for travelers on the autism spectrum[8].



Passageways

The design of passageways, the collection of spaces - such as **corridors**, **travelators**, and **escalators** is crucial for facilitating wayfinding and spatial orientation



DESIGN DECISIONS

Airport terminals are complex buildings that must accommodate a wide range of functions and user groups. A particularly challenging aspect of terminal architecture is the design of passageways, the **collection of spaces - such as corridors, travelators, and escalators** - within which passengers navigate the airport.[2] The design solutions deployed in these spaces can facilitate **wayfinding** and spatial orientation for passengers, making passengers feel more at ease and thus willing to spend money in the commercial areas of the terminal building[3]. In contrast to the low ceilings and confined spaces of security and immigration, corridors in the passenger area are usually wide open, well-lit spaces[4]. However, a space that is more open than necessary produces challenges of its own:

> "Overdesign, either as a simple expedient for avoiding future congestion or for the aesthetic of open spaces, can also be most expensive. For example, the decision to make the central corridor of the 180 m. long corridor of finger pier of the new two level Sydney 1TB 12m wide, instead of a feasible 6m, implied an extra capital cost of about US $4 million." [2]

Current design guidelines suggest that **every foot of passageway width should accommodate 16.5 passengers per minute**.[5] This formula provides a rough guideline for the minimum free-flowing width to maintain around pinch points such as restaurant entrances and kiosks. Passageways often include subtle design features that help guide travelers through the airport. Flooring materials and ceiling designs can include patterns oriented in the intended direction of travel, and natural or artificial lighting can be projected onto the path.[6]

EFFECTS ON PASSENGERS

A study conducted in Amsterdam's Schipol Airport in 2008 on consumer preferences in the design of airport passenger terminals found that the **most preferred passenger area features a wide, curvilinear floor plan**; a curvilinear roof; a light-colored floor; warm, atmospheric lighting; the presence of plants or other greenery.[1] The key findings and relative weights of each design characteristic are summarized below:

> "Passengers prefer the form of a curvilinear roof over that of an orthogonal roof (0.78), and clearly prefer the use of white materials over black materials (0.77). Passengers also preferred wood-coloured materials over black materials (0.37), but not as much as they preferred white materials over black materials. A curved layout is another design characteristic that is more important than dimensioning, wood-coloured materials, use of warm lighting and no decoration underscoring the distinctiveness of Holland, but its impact is comparable to that of greenery. In general, passengers preferred an area with a curvilinear roof, a curved hallway, the presence of greenery, no decoration emphasizing the distinctiveness of Holland, the use of warm lighting, a wide dimensioning and an emphasis on white materials (i.e. a white floor, shop atmospheric and roof)." [1]

While van Oel and van den Berkhof's study found that passengers preferred designs with no reference to the 'distinctiveness' of the terminal's geographic location, other studies have found a positive relationship between expressions of national identity in the design of terminals and the delight of passengers.[7]

Passport

Perhaps the object we are most conscious of at airports is the passport.

DESIGN DECISIONS

The passport is a travel document issued by a country to its citizens, that identifies the holder's name and other descriptive categories. Passports are used to identify a person, as **a tool by which the state may enforce their authority over one's movement**. These passports standardize travellers into delineated categories such as one's hair color, eye color, height, and birthplace. As Löfgren writes: "as a traveller you now had to live up to your passport identity to be able to prove your identity." [1]

"As a traveller you now had to live up to your passport identity to be able to prove your identity." [1]

The **size of passport booklets** is standardized internationally, around 125 × 88 mm (4.921 × 3.465 in), in accordance with the ISO/IEC 7810 ID-3 standard[2]. Many countries have begun to issue **biometric passports**, containing an embedded microchip which makes them readable by machines.[3, 4]

EFFECTS ON PASSENGERS

Passports and immigration stamps are a **useful reminder of travels.** These can serve as mementos of adventures past, and some travellers "collect" immigration stamps, deliberately entering or exiting countries by different means (for example, by land, sea, or air travel) to receive different types of stamps.

Passengers can have significant anxiety around the possibility of losing one's passport. These people take comfort that new biometric methods of identification, such as facial recognition scans, have started to replace passport checks, and may make paper passports obsolete. On the other hand, other passengers have privacy concerns about the biometric additions to passports, or the prospect of having all identification being done by biometric scans. With new biometric passports, the RFID chips can be read surreptitiously which can pose both privacy and identity theft concerns.[5]

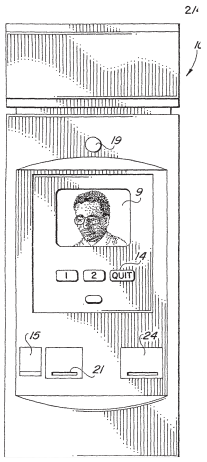
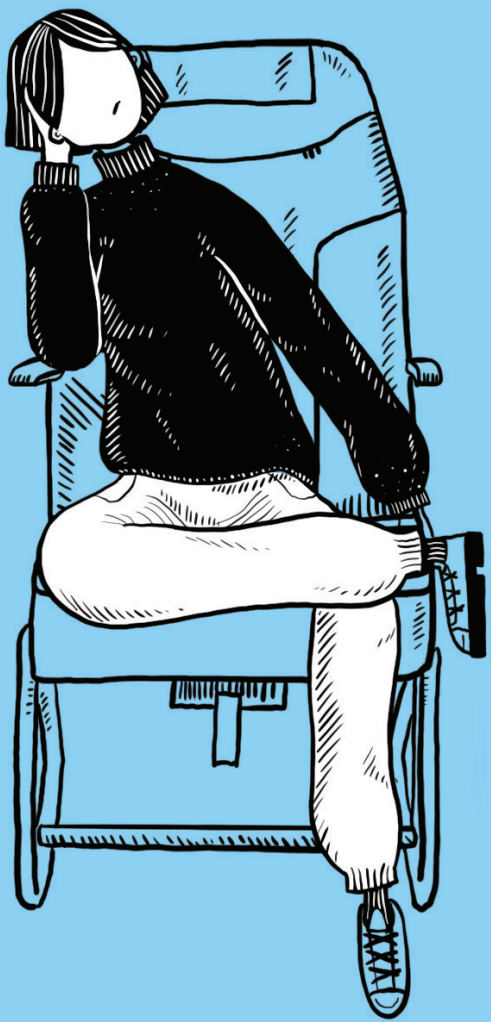


Figure 2. Passport kiosk using biometric scans.

PAX

"The PAX is an abstraction, a simplification of real passengers, a generalisation of what real passengers look like, think or feel."



In the aviation industry, passengers are typically referred to as PAX. One report summarizes the basic contours of the PAX as "**a unit regarded as being of a basic standard, usually miniscule in size, somewhat lacking in both intelligence and general ability to find his way about** (especially if he is a holiday traveller on a package tour)."[2] Contemporary airport stakeholders often utilize the imaginary figure of the PAX in computational simulations to evaluate the suitability of a particular architectural design or set of processing procedures.

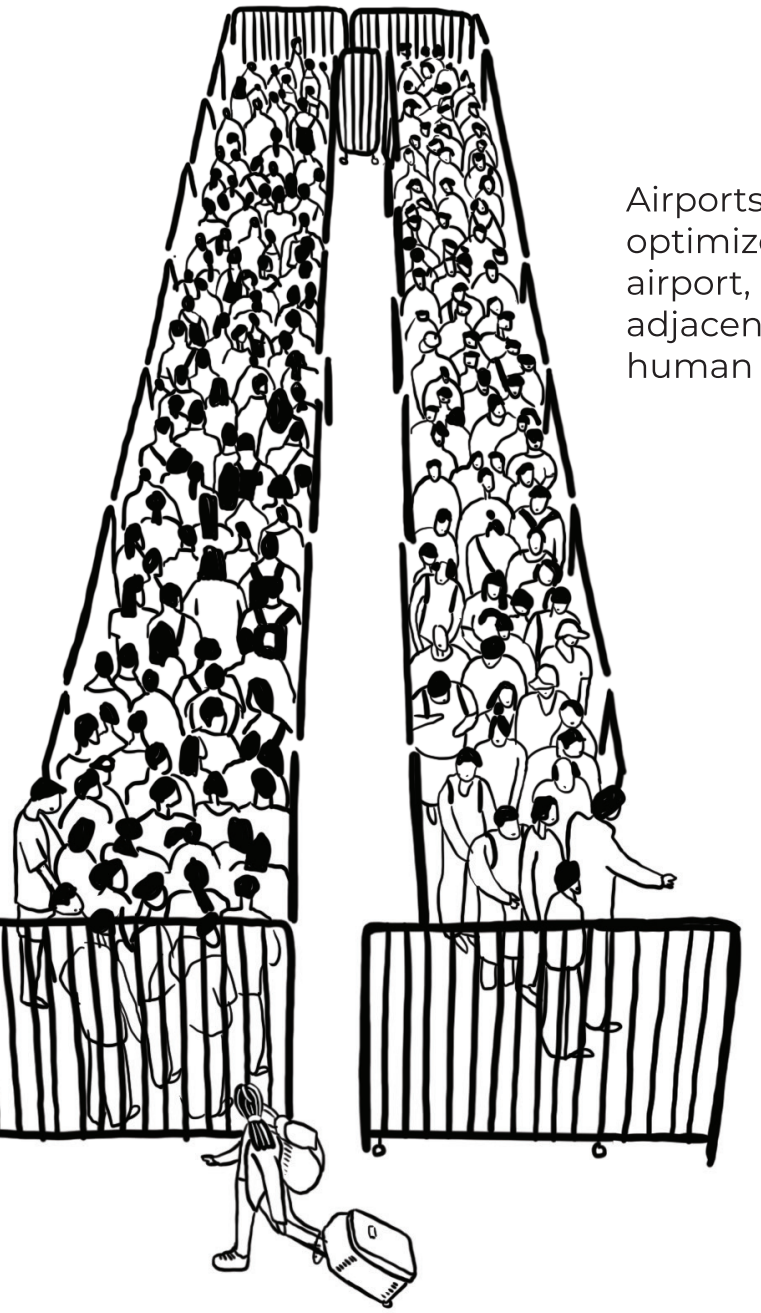
Whereas in the past passengers were simply customers, today they are also expected to act as civilian officers who extend the work of security workers beyond the checkpoint[4].

Depending on the particular goals and versions of success held by a given stakeholder, PAX can be passive entities with prescribed routes, "**stressed individuals** who are always at risk of becoming too confused to be in control as well as subjects choosing their activities as they please and navigating the airport with confidence." [3] However, recent research has sought to reconceive the passenger as more than just a homogenous entity. **People travel for a diverse range of reasons**, respond to the stress of travel in radically different ways, and the specific needs for each user can be quite different.

A recent study sought to reclassify passengers based on four interrelated categories - **time sensitivity**, **degree of engagement**, **proficiency**, and **travel purpose**.[4] The study identified two key relationships that define passenger behavior - a direct relationship between passenger time sensitivity and proficiency, and an inverse relationship between time sensitivity and engagement. Of the 167 passengers interviewed in the study, none displayed the characteristics of the passenger type typically targeted by airport designers, namely a traveler with a high sensitivity to efficient processing and a desire to engage with airport amenities.

As air travel is becoming an increasingly popular means of global transit, **the "typical" air traveler has become more and more difficult to define.** Often, specific aspects of passenger profiles are mobilised to justify designs serving particular goals and achieve versions of success that different groups of "airport-makers" strive towards.[3] The less that airport stakeholders attempt to simplify this diverse constituency, the more insightful their approaches to airport design will be.

Queues



Airports have learned to optimize queues at the airport, drawing from adjacent industries and human psychology.

DESIGN DECISIONS

Waiting in lines at the airport to be processed - at check in, luggage drop off, security check, boarding, and customs - correspond with time periods where passengers experience the most elevated levels of stress, anxiety, boredom, and other negative emotions. Airports and airlines employ a combination of methods to process large numbers of people. To do so, **air travel operations draw extensively from queueing theory**, a branch of mathematics studying the waiting of lines.

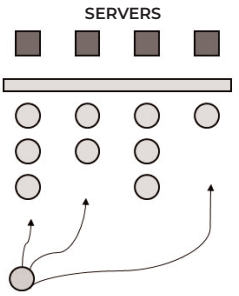
Aside from the air travel context, queueing theory is used to design the operations and spaces of retail, factories, offices, hospitals, and supermarkets, from efficiently processing DMV applicants, to sorting incoming patients to the emergency room in terms of order and urgency. Its relevance also extends to telecommunications, traffic engineering, computing, and much more.

Because of this, airports have been able to **learn from these adjacent industries** as they experiment with various types of in-person queuing. The three most common types of queues are as follows:

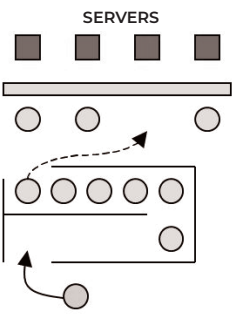
1. **Single I-shaped line** of customers, for 1 counter
2. **Multiple I-shaped line**, for multiple counters
3. **Single S-shaped line**, for multiple counters

The first type of queueing is the most simple and intuitive, but it is not used often at the airport due to the large numbers of people to be served. The second type, the **multiple I-shaped line**, is the more traditional type of queue line and is ubiquitous in many contexts.

However, the most popular type of queues today is the third type, the **S-shaped line**, where a single line is arranged in a compact S-shaped form, from which passengers can be served at multiple counters as they become available.[2] It is more time efficient and space efficient than the multiple I-shaped lines, through its better grasp of **human psychology**.



Multiple I-shaped queue



Single S-shaped queue

Figures 1 and 2. S-shaped queue (above) and I-shaped queue (below)

EFFECTS ON PASSENGERS

Why might this be the case? **Multiple I-shaped lines are less efficient than a single S-shaped line**, because the former motivates customers to follow one of four behaviors:

1. **Staying**: customers stay in the queue until they are served
2. **Switching**: customers switch between queues if they think other queues are shorter
3. **Dropping Out**: customers leave the queue if they have waited too long, and seek alternatives

An important reason for the inefficiency of multiple I-shaped lines has to do with what economists call the "**last place aversion**".[3] Standing at the last place in a line leads people to feel significantly less satisfied than if someone is standing behind them. Those in a particular place in a queue were 4 times more likely to drop out when there was no one else behind them, and twice as likely to switch to another queue, even though by doing so they typically waited even longer to get served.[3]

"When we join a queue, we tend to make the most rational choice we can, which usually means joining the shortest queue. But if we see a line moving faster, we might switch without having enough extra information, and we can often get it wrong." [3]

In other words, **people often switch between queues if they think another is shorter, but they are bad at assessing whether a line is truly shorter**, and the excessive "switching" or "dropping out" slows down service for everyone.

To dissuade people from this consumer queuing behavior, airports as well as retail stores have increasingly adopted the S-shape type of queues. S-shaped lines also make it more difficult for people to estimate the true length of a line. In addition, S-shaped lines are perceived as most fair; as there is only one line and it is strictly first come, first served, and no one arriving later than another is served before them.

Rituals

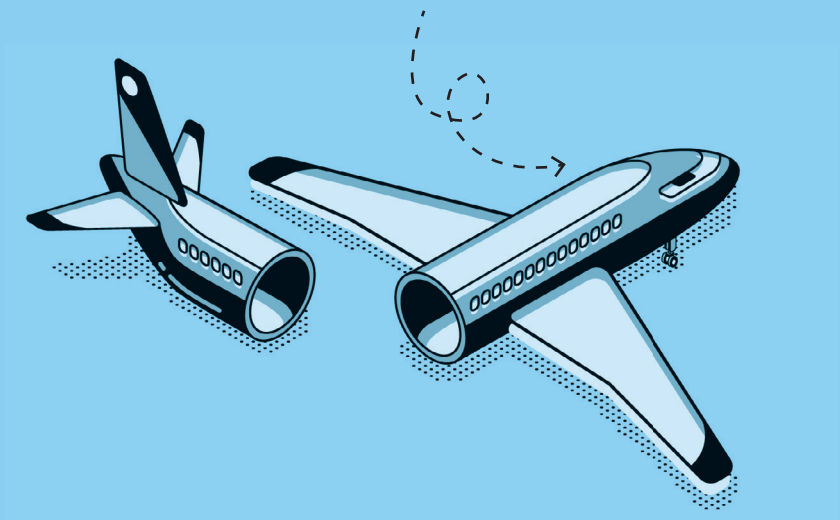
People develop tactics such as routines and rituals to give themselves the illusion of control

Many passengers develop pre- or during-flight routines, ranging from fairly conventional to truly idiosyncratic. These routines may be practical, such as having a pre-planned list of items to pack. Others may be less so, such as elaborate multi-step rituals that help distract passengers from their anxieties surrounding flying.[1]

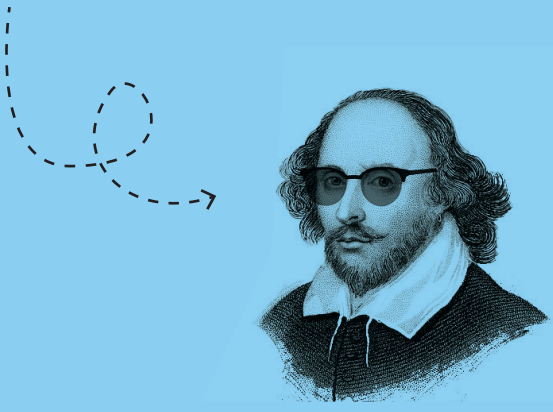
> Clean everything you touch. Anything that you put your hands on, you have to wipe. This is what I do on every plane I get on. **I do not care what people think of me**. It's my health, and it makes me feel better.[2]

> I have a friend who's super anxious about flying, and he always convinces the flight attendants to let him keep his tray table open during take-off. Then he puts a framed painting of Virgin Mary on a tiny stand, opens a Bible to a marked passage, **says a little prayer**, and then **downs Xanax pills** with two champagnes.[1]

“Flying is weird for me. **I always try to sit near the front, so I can’t see the vastness of the plane**. I kind of freak out when I realize how many people are on it. I usually hyperventilate at some point during the flight - kind of to myself, so no one else notices.”[1]



“When I was young, I used to recite a **Shakespeare sonnet** in my mind during take off. It’s like a race. Once the plane starts moving, I start and then **try to race to finish it** before the plane leaves the ground. It’s like a way of measuring the amount of time it takes for the plane to take off.”[1]



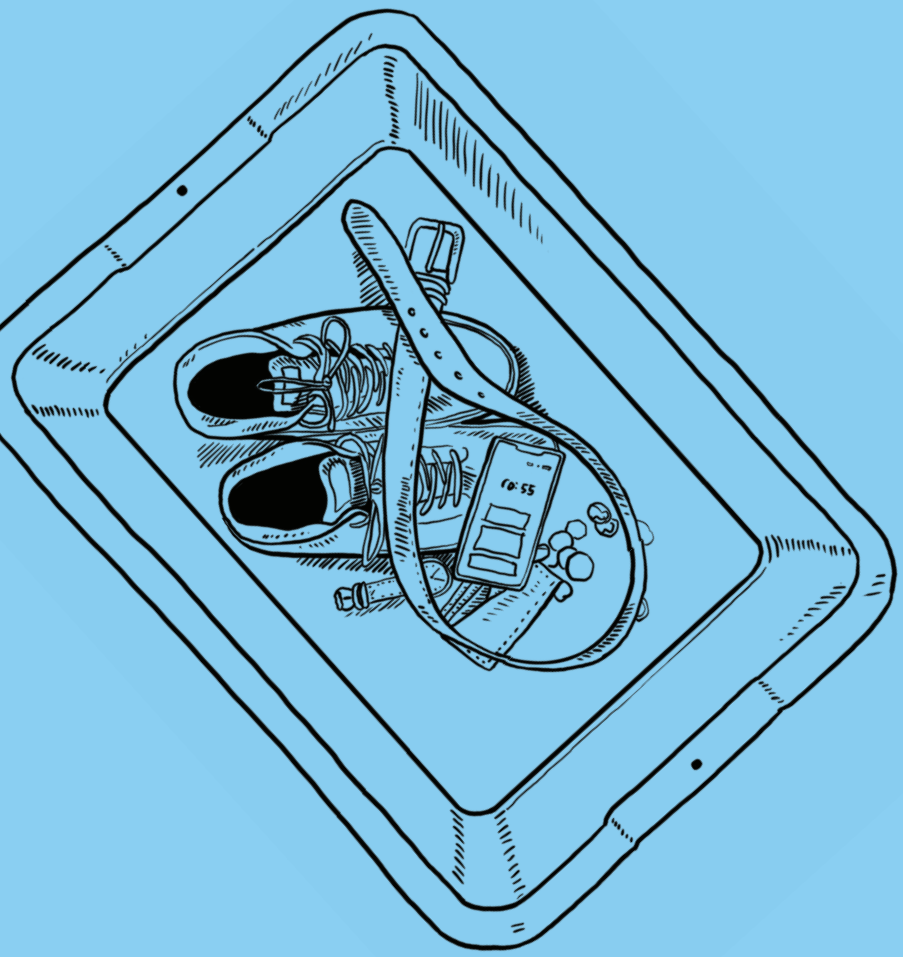
> I have a pretty extensive Excel sheet with a packing list, organized by seasons. I have it down to a science now. I don't really have to think about it - **just open the spreadsheet and go**. [1]

> I always buy three magazines in the airport beforehand - usually ***Automobile***, ***Dwell***, ***Yachting***, and maybe ***Auto Trend***. They always some sort of lifestyle component to them - like fancy cars, fancy houses, and yachts, and they make me forget that I'm flying. They make it easier to escape the present reality. [1]

> Always step onto the plane with the **right foot for luck** - everybody knows that.[1]

Safety

Our concerns for safety stem from both human nature and from well-publicized disasters.



Following well-publicized major air travel disasters and terrorist acts of the 1980s, all stakeholders in the air travel system—airlines, passengers, government regulators and policy makers, airport space and infrastructure architects, etc—have prioritized safety and security beyond almost any other concerns.

In the airport, one way this became visible was in the spatial changes to the architecture of the airport security check and terminals. Following the terrorist attacks of the 1980s, "intensified security measures changed the planning of airports, deliberating cutting up the open flow of spaces."[1, 2]

Therefore, a main consequence of the increased screening after terrorist attacks is that the **airport became spatially segmented as "pre-security" and "post-security" areas.** Centralized security "choke points" were relocated to a dedicated area far away from the boarding gate. This provided a buffer in the form of distance, making it difficult for would-be hijackers to get near a plane, but also allowing space and time for those who successfully pass the security checkpoint to be identified prior to the gate.[3]

The increased distance between the security checks and boarding the airplane made it necessary to develop the lounge concept. Passengers were put in a hold situation once they were processed through security, with nothing to do except to wait. A common way for airports to pay for these increased security costs was to increase revenue by expanding retail. Today, the airport experience is inextricably intertwined with the retail experience for most passengers. **Commercialization of airports can be understood as a major consequence of these terrorist attacks, including 9/11**.[4]

Passengers are also enlisted to contribute to **peer surveillance**, whether explicitly or implicitly through stoked fears of covert terrorist agents. Signage and posters around airport spaces serve as

Whereas in the past passengers were simply customers, today they are also expected to act as civilian officers who extend the work of security workers beyond the checkpoint.[4]

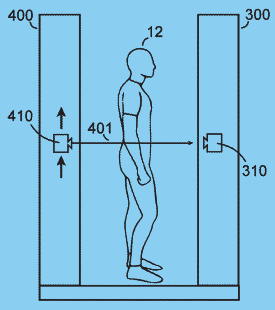


Figure 1. X-ray scanning meachanism for people.

"If You See Something, Say Something."

constant reminders to passengers as well as all airport personnel that they must always remain vigilant and proactive in reporting suspicious items, persons, and behaviors. This is evident in the ubiquitous messaging, "If You See Something, Say Something." To fly, one must serve in this public safety task; Hall notes, one "must perform voluntary transparency." [5]

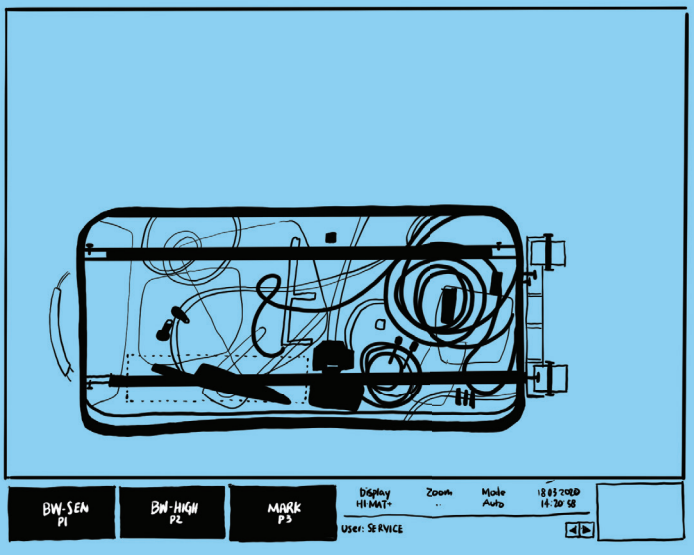
In the airplane, **safety considerations are a major requirement of all design decisions**. Most airplane components take into account the likelihood of its parts coming apart and causing injury to the passenger in the case of an accidental crash. They must also be flame retardant in the event of an accident. Extensive regulations govern the specifications that manufacturers must meet for any airplane component.

Additionally, safety concerns mediate many of the activities that passengers are allowed to partake while on the plane. Seatbelt usage is not only required, but also are actively visually checked by flight attendants. Passengers must remain in their seats upright and their seatbelts fastened during take-off and landing, and are generally encouraged to stay in their seats throughout the flight if possible, excluding occasional lavatory usage. Safety cards, videos, and demonstrations are a ubiquitous part of every passenger's experience on the plane.

(See also: *Security Theater*).

IF YOU SEE SOMETHING, SAY SOMETHING.

BE SUSPICIOUS OF ANYTHING UNATTENDED



Security Theater

Security Theater is measures that make people feel more secure while doing little to effectively improve their security.

Security theater refers to security measures that make people feel more secure, but by definition, do little to truly improve their security. This often involves restricting aspects of people's behavior in very visible and highly specific ways, or prominently displaying security equipment to give the appearance of surveillance[1,2]. Restrictions of people's behavior, personal liberty, and privacy rights can range from negligible to significant. Security theater, as a term, is not neutral; it specifically refers to **security measures that are more for spectacle than efficacy**.

Examples of security theater include random bag searches on subway systems, a practice used by Washington DC's transit system - among other cities - whose program yielded zero arrests[3]. Another example is TSA's Screening Passengers by Observation Techniques (SPOT) program, a behavioral-detection program introduced in 2007 that sought to detect terrorists, which cost $900 million but was revealed to have exposed no terrorists.[4]

Security theater measures are often specific and reactive to particular events, such as requiring the removal of shoes after the 2001 "shoe bomb" attempt, and utilizing full body scanners after the 2009 "underwear bomber" attempt. Because of this, privacy and security advocates have argued that measures such as the removal of shoes, electronics, and liquids for separate scanning can be likened to a "fishing expedition," as attackers simply divert to other strategies[2]. Many have demonstrated the ease with which existing airport security measures can be tricked or hacked.[3, 4, 5]

However, **others have also argued that the perception of security may also be as important as actual security itself**.[6] The feeling of protection or safety could allow people to carry on activities that they would have otherwise avoided. In this understanding, a possible benefit of security theater is to encourage people to take part in society as they normally would, particularly in the atmosphere of uncertainty after well-publicized accidents or terrorist attacks. However, **not all passengers are afforded the feeling of protection equally**, as security theater can result in prolonged screening of specific minority populations to the point of harassment.

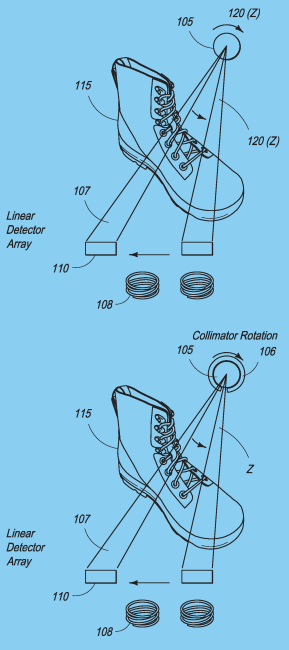


Figure 1. X-ray scanning of shoes for explosives.

"Security is both a feeling and a reality. The propensity for security theater comes from the interplay between the public and its leaders. When people are scared, they need something done that will make them feel safe, even if it doesn't truly make them safer. Politicians naturally want to do something in response to a crisis"[7].

Signage

"Graphical signage cools down the anxiety of unfamiliar terrains and replaces it with a familiar authority—the sovereign structures of transit systems"[1].

DESIGN DECISIONS

There is a sign for nearly everything at the airport. In contrast to the landmarks, mental maps, and paths used to explore urban environments, we use signs to understand our position within the complex infrastructure of air travel.[1] **Signs at the airport direct, inform and identify** the various flows, jurisdictions, spatial arrangements and procedures of air travel. They are such critical components of the airport navigation experience that significant resources are devoted to quantifying the criteria for effective sign design.

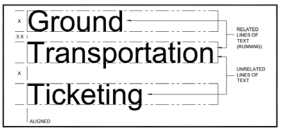


Figure 1. Line spacing examples

National entities have published signage standards such as the FAA's Guidelines for Airport Signing and Graphics or the BAA's British Airport Authority Signs Manual. Fonts, formatting, placement, color, background, and hierarchy are just a few of the myriad design characteristics that have been evaluated and quantified by researchers and airports.

Figure 2. Spacing example relationship between arrow, symbol, and text

Creating legible, concise signage to direct a multitude of complex flows of both goods and passengers has historically been a challenge for designers.[2] A variety of methods have been deployed with varying degrees of success. **Colorcoding** was a popular strategy in the 1960s and 70s, particularly in the United States, though this strategy fell out of favor partly because roughly 12% of the population is color-blind.

Today, airports employ a range of strategies. **Signs usually feature a combination of words and pictograms**, following the graphic standards and best practices established by various regulatory agencies. Font choice has been standardized to such a degree that 80% of airport signage uses one of three fonts: Helvetica (42%), Frutiger (32%) or Clearview (6%) (Waller). Each font shares similar characteristics: open counters, large x-heights, and consistent stroke-width ratios that all support the legibility.[2] Alternative navigational strategies have also been employed. For instance, **public art is often deployed as a navigational aid**, or placed in such a way that it draws air travelers into a particular zone in the airport.[4]

"We have a sauna in the airport and the pictogram for that is a person sitting in a room surrounded by snowflakes," says Copenhagen's Mr. Haugaard, who himself finds that design a bit oblique. Today, European airports retain only the occasional pictogram, and usually accompany it with simple words."[3]

EFFECTS ON PASSENGERS

"The arrow... turns place into passage, striates space into controlled flows, and urges the traveller to 'move on'. It is a point sign that leads the way to a consideration of the technologies... that provide the navigational and behavioural guidance that is increasingly in evidence, not only at the airport but in all public spaces"[1].

The prevalence and importance of signage in the space of the airport was examined by Marc Augé in his seminal 1995 text Non-Places. He writes that "The link between individuals and their surroundings in the space of non-place is established through the mediation of words, or even text." [5] Lacking the distinct physical landmarks and heterogeneous characteristics of urban environments, signs become an essential component of wayfinding and spatial legibility at the airport. **Great signs go unnoticed** - they seamlessly facilitate the users to find their way within the airport. Illegible signs, however, can induce stress, confusion, feelings of incompetence. Methods have been developed for quantifying topological complexity of floor plans.[6]

From a typographic perspective, recent research has shown that contrary to expert predictions, alternative typefaces can be just as legible as the ubiquitous san-serif typeface. In one study, "character width was a more significant factor in legibility, with condensed sans serif performing relatively poorly. The use of multiple methodologies led to a richer basis for decision-making: the qualitative research revealed clear genre expectations among airport users for sans serif signs; the expert reviewers raised a range of additional issues of genre, culture and context." [7] Passenger experience level has been shown to impact preference for particular navigational aids, with infrequent travelers relying equally on maps and signs and frequent travelers preferring to navigate the airport using signage alone.[8]

One challenge that many passengers face in interpreting airport signage is due to the fact that **signs convey information about three-dimensional navigation on a two-dimensional surface**[8]. This introduces a certain degree of ambiguity and confusion as, for instance, the same arrow can be read as pointing "up" or "straight ahead".

Figure 3 Recommendations from the Airport Sign Managers Network at San Jose International Airport

Space

"The strategies used in airports to circulate people, cargo, and aircraft constantly change due to new logistical and security demands, technological developments, and shifts in socio-political conditions"[1].

Architects and planners have developed a number of tools and techniques to calibrate a passenger's spatial experience of the airport. The size and shape of design elements, from the form of the terminal building to the dimensions of the check-in counter, can dramatically influence a passengers perceptual experience. The accurate forecasting of quantitative data, like the anticipated number of air travelers, as well as qualitative metrics, such as the amount of time the average passenger will tolerate waiting in line, is instrumental in guiding these design decisions. As a result, airport stakeholders employ a number of strategies to estimate the overall number of passengers, and predict passenger preferences during the various phases of air travel.

1. **Form**
2. **Level of Service**
3. **Personal Space**

FORM

Though airports all share the same basic function, there is hardly such a thing as a typical airport layout. While passenger experience is of course a key design consideration, the form of each terminal is sculpted by a confluence of external factors including established flight paths, runway layouts, natural and urban contexts, and the potential for future airport expansion.

"While wayfinding is a significant aspect of air terminal design, the main determinant of the building's overall form is the airport's runways. These vast expanses of tarmac occupy most of the airport's landmass, and they are relatively fixed once they have been developed"[1].

At the largest scale, the general configuration of an airport terminal influences key metrics such as the travel distance between the different aspects of the airport experience, including check-in, security and the departure lounge. The suggested maximum walking distance between major functions (eg. check-in to security; security to departure lounge) is 300m[2].

As a result, **though many airport designs share**

similar spatial arrangements or typologies (ie. linear, pier, satellite, transporter) **there is no consensus on the ideal spatial configuration**, and airport designs show a high degree of formal diversity[3]. From the perspective of passenger experience, this wide catalog of design solutions means that there is no universal strategy for navigating an airport. Instead this diversity means that "problem-solving skills are demanded of passengers and visitors" for each new airport encountered[4].

LEVEL OF SERVICE

"It easily and quite predictably happens that a terminal with enough space... in fact has a number of significant problem areas which make the building feel, and thus be, inadequate"[5].

A successfully designed airport terminal needs to satisfy the needs of three primary user groups: the **passenger**, the **airline**, and the **operator of the airport**. Of these groups, passengers significantly outnumber other airport users and represent a significant source of airport revenue. In many ways they are the primary reason for the airport to exist. The accommodation of passenger needs is thus undoubtedly a key component of terminal design[6]. According to airport scholar and researcher Brian Edwards, a well-designed airport is defined as one in which "jaded passengers ferried from building to plane and terminal to gate, can find tranquillity and peace"[7].

For the last 50 years, airport stakeholders have sought to develop a method to evaluate the design and operation of terminals from a passenger experience perspective, frequently through level of service standards. **Level of Service (LOS) refers to the spatial and temporal framework developed by aviation stakeholders to explicitly specify the size of a particular space in the airport, and how much time a typical passenger should spend there**. First developed in the 1970's by the International Air Transport Association (IATA), the standards are intended to assist architects, engineers, airlines and airport owners in making design decisions and form the basis for translating demand forecasts into an architectural design[8]. The standards are generally expressed as letter grades - which reflect the percentage of passengers who will find a given wait time or amount of space adequate - and include per-occupant area requirements for both standing and walking behavior.

Odoni and de Neufville summarized the key decision embedded in this design process: “Higher standards imply more space and cost, and these have to be made compatible with the financial objectives of the owner or operator of the terminal. The level of detail at which the step is carried out varies greatly from airport to airport, and the results may also be very different”[5].

Despite the dramatic changes to the air travel experience over the last 50 years, the basic contours of LOS standards have remained largely unchanged since their inception[8]. However, the precise factors to include in a LOS evaluation are a subject of continual debate among airport stakeholders, and no universally accepted method exists for measuring LOS for airport terminal buildings[9].

Level of service standards often rely on **a careful estimate of the rate at which passengers that will be flowing throug**h a particular space in the terminal. For purposes of design, this forecasting relies on a metric known as the **design hour**.

The design hour has historically been calculated via a number of different metrics, depending on the available data and the precise makeup of flights at a given airport. One common approach defines the **design hour as the 90-95th percentile busiest day of the year**. Determining this hour requires a data-intensive, precise tracking of passenger flows for each flight during the year to find the activity level which represents 90-95% of the maximum level of traffic. Other approaches include defining the design hour as the peak hour, on an average day during the peak month[10].

“The objective of this exercise is to produce highly detailed, peak-hour demand scenarios for the design day many years ahead. These figures provide the basis for the actual design. It is a most speculative enterprise. This forecasting process normally first estimates aggregate traffic for the ‘target year’ for which a new, expanded or modified terminal is being designed. This aggregate forecast, in turn, is converted into a further estimate of traffic for the ‘design day,’ normally taken to be the 30th or 40th busiest day of the year, or something such as the ‘average weekday of the peak month’”[5].

PERSONAL SPACE

Beyond estimating the quantitative aspects of passenger travel through the airport, a better understanding of more qualitative aspects - such as potential areas of crowding - can help airport stakeholders more precisely allocate space. Research has often questioned the adequacy and robustness of the various quantitative standards. Odoni and de Neufville identified that one "problem with these standards is that they assume that the space provided for an activity will be useful, no matter how or where it is provided. Implicit in the formula is the idea that the occupants of a space somehow disperse to make use of an entire area. People are not gasses, however, and unfortunately no such physical law exists for them"[5].

Patterns of traffic concentration are "usually quite easy to anticipate, and avoid. People, for example, naturally cluster around information booths, the first queues in front of them in any set of parallel queues, the mouth of the baggage chute, telephone banks, etc. These facilities should thus not be sited where they could cause bottlenecks"[5]. The wide range of factors to consider is one reason for the difficulty in developing a universal approach. One recent review of LOS metrics for departure lounges identified space available for circulation, number of available seats, and waiting time as key factors, but noted that concessions, lighting, announcements, comfort and aesthetics could all impact passenger perceptions of a terminal[11]. Adding to the complexity of quantifying passenger experience is that "...the same airport can be perceived differently: as a familiar or home airport for frequent patrons and a destination airport for other passengers "[12].

A number of models have been developed to simulate passengers' behaviour inside airport terminals. Microscopic models focus on a reliable and detailed evaluation of the complex movements of every passenger[13] while macroscopic models analyze the nature of queues in general[14]..

WHAT IF?

A primary component of controlling the spread COVID-19 is preventing people from coming in close contact with each other, as inhalation of aerosolized virus particles from another person is the most common method of transmission. It is an inherently spatial crisis. All preventative measures currently in place make use of increased physical distancing between individuals. Many facets of passenger experience of air travel will be modified to reflect this new spatial dynamic, including airport check-in, security, immigration, the departure lounge and boarding. Much like the borders and boundaries for sorting and screening established after 9/11, a post-COVID air travel experience will define new spatial relationships between individuals, and new ways of interacting with the physical space of the airport.

Time

"A body [is] held between the nether space of depart and arrive, a time which exists as countdown: nine hours, five minutes until arrival, eight hours, twenty-five minutes until arrival"[1].

In comparison to other modes of transportation, commercial **air travel subjects passengers to a unique mode of bodily and mental disorientation**. While this disorientation includes a **spatial** component (in the sense that passengers physically inhabit the liminal spaces of the terminal and aircraft), certain **temporal** elements may more strongly influence passenger perception. Time is measured differently during air travel. It is often a subjective, event-based metric, expressed as a **T-minus countdown** to an upcoming milestone, rather than an objective reference to the time of day in a specific place. Dodge and Kitchin[2] further argued that air travel, combined with modern communication technologies, transforms existing space-time relations. In this unique configuration, time and space become fluid, creating simultaneous presence and timelessness.

While the general aesthetic of airport terminals and aircraft "works to inculcate a sense of smoothness and transparency in movement" this aesthetic is often in contrast to the series of queues and extended periods of waiting experienced by passengers as they move through the terminal[3]. In air terminals, **anxiety associated with the feeling of running out of time** is a crucial variable that determines the degree of passenger engagement in the terminal. **This time-based urgency exists alongside extended periods of waiting, queueing and boredom.** In flight, the lack of a proprioceptive awareness of physical distance traveled means that "...spatial distance [is] temporalized. In concrete terms, for the jet traveler, the spatial relationship between New York and Los Angeles is not 4500 km but a safety announcement, two movies, snack service and a promotional travelogue"[4].

From the perspective of the passenger, optimum timing of events makes for a lower stress, smoother travel experience. Etymologically, travel is linked to "travail", meaning a painful or laborious effort[5]. The philosopher Bruno Latour writes about the relationship between transformation and transport, proposing that the passenger experience of travel depends on the quantity and amplitude of interventions by others. He writes, "[t]he speed of the [airplane] and the uneventful trip of the passenger are entirely dependent on the complete obedience of the places that are traversed

and also, of course, on the smooth functioning of the [airline's] organization, running, as the saying goes, like clockwork"[6]. The focus of the airline industry is to minimize the disruption of such unplanned events, - missed flights, weather delays, extra security screenings - reframing the journey over vast distances as a smooth, easy passage.

WAITING

"It was appropriate, perhaps, and not paradoxical, that terror should also sharply promote its most obvious opposite. ***Boredom****"*[8].

DESIGN

Passengers must satisfy a series of legal and regulatory requirements at the airport before they are allowed to board an aircraft. These activities, collectively referred to as **processing activities**, include checking in, filling out any required departure paperwork, and negotiating security and customs checkpoints. Though processing activities are an essential part of air travel, research shows that passengers are only engaged in them during a small portion of their time at the airport. One study found that the average passenger spends only 4% of her time in the airport actively participating in processing activities, while time spent waiting to be processed accounts for another 25%[9]. Others have drawn similar conclusions, such as a recent study by the Queensland University of Technology that reports passengers spend on average just one-third of their overall airport dwell time undertaking or waiting to complete processing activities[10].

The majority of passenger time at the airport is thus devoted to other, non-essential activity. This class of activity is commonly referred to as **discretionary activities**, and includes eating, shopping, sitting, etc.[11]. Other studies have characterized this class of activities as "**enforced leisure**" time[7].

The duration of passenger dwell time at the airport can

also be influenced by factors outside of the terminal building, such as reducing variability of travel times to the airport terminal. Odoni and de Neufville cite an example of a departing traveler who incorporates a 30 minute cushion in her travel plans to accommodate for any delays in travel to the terminal. "She pays a penalty of 30 minutes on the average, as a 'hedge' against the variability of ground access time. This same penalty is also paid by the airport in having to accommodate an additional 30 'person-minutes'. Her **airport dwell time**-and the 'loading' she imposes on the terminal's facilities, mostly in the form of additional Passenger terminal design 'slack' time-could be reduced, up to a point, in direct proportion to any reductions in the standard deviation of ground access time"[7].

"Travellers are forcibly waiting. In particular, travelers in transit between two stages of a journey may be waiting between one and three hours, or even longer, and are looking for something to do to fill their time. They are experiencing enforced leisure in an environment in which they may have little to do"[7].

EFFECTS

A passengers experience of the airport is significantly influenced by the amenities provided and general physical characteristics of areas designed for discretionary activities. Well-considered amenities can reduce perceived waiting time for passengers and result in an overall positive view of "enforced leisure"[12]. A taxonomy of discretionary activities developed recently by researchers at the Queensland University of Technology divided this diverse **mix of activities** into several categories - **preparatory, consumptive, social, entertainment, passive, queuing, and moving**[12]. The study noted that most existing research has focused on passenger experience during processing and consumptive activities, though evidence suggests that improvements in other types of discretionary activity (such as preparatory activities, during which passengers are preparing to partake in an upcoming processing activity) can have a significant improvement on passenger perception of processing activities.

WHAT IF?

The airport could suggest the optimal time to engage

in each processing activity? Recent work by Rossi, et al. developed an experimental model to make activity suggestions to airport passengers in order to reduce the amount of time that a given passenger spends in processing/queuing activities, thus increasing the amount of time they have available to participate in discretionary activities such as shopping or eating - simultaneously increasing passenger satisfaction and airport revenue[13]. The simulation relied on historical mobile phone trace data to predict passenger behavior.

DWELL TIME

DESIGN

Dwell time refers to the **total amount of time that a passenger spends in the airport** prior to boarding her flight. For a variety of reasons, particularly the increased security **following the 9/11 attacks, there has been a significant increase in average passenger dwell time**[15]. Today passengers arrive very early for their flights. As recently as the late 1990's, average passenger dwell time was about 50 minutes[16]. More recent figures report the average dwell time as substantially higher. A recent report on passenger behavior in Amsterdam's Schiphol Airport reported an average dwell time of 146 minutes per passenger - an increase of nearly 200%[17].

Even before the 9/11 attacks, airports '"tended to encourage longer dwell times through the provision of extensive shopping areas, restaurants, etc. within airport terminals. This has been particularly true of international terminals, where many Airport Authorities have reaped rich financial rewards from such ancillary facilities located in duty-free areas"[18]. This trend has been amplified by the increasing importance of non-aeronautical revenue in the profitability of airports. Now, instead of experiencing

waiting as wasted time, passengers are encouraged to engage in shopping, dining, and other forms of retail spending. Within the near-constant motion of air travel, dwell time is a brief period of immobility which airport stakeholders consider an ideal time to entice passengers to engage in commercial activity[19].

Beyond its economic implications, the metric of dwell time is used for the planning and sizing of airport facilities. Dwell time is "central to determining the number of simultaneous occupants. For instance, if the flow of passengers through a lobby is relatively uniform over time at a rate of 900 per hour, and if dwell time is 20 minutes or 1/3 of an hour, then the number of people in the lobby at any time is 900 x 1/3 = 300. Thus, space needs to be provided for 300 people, not 900"[18]. Additionally, "[s]horter dwell times are, in fact, the principal reason why the part of airport terminals allocated to arriving passengers requires considerably less space than that for departing passengers"[18]. While increased dwell time has positive implications for revenue generation, it requires an equivalent shift in scale of terminal architecture along with an increase in operating costs[18].

Within the near-constant motion of air travel, dwell time is a brief period of immobility which airport stakeholders consider an ideal time to entice passengers to engage in commercial activity[19].

EFFECTS

Dwell time can be controlled and manipulated in a variety of ways. Design elements such as information screens and comfortable seating can slow down passenger flow and increase dwell time in specific areas, while limiting information about gate assignments can 'force' passengers to congregate in central, retail-heavy areas of a terminal[20]. In many cases, simple amenities such as seating with cup holders or electrical charging capability can influence a passengers desire to remain in a certain space[21].

This relationship between time sensitivity and degree of passenger engagement has been used to create passenger profiles, such as "airport enthusiast" (engaged and non-time sensitive), "time filler" (non-engaged and non-time sensitive), "efficiency lover"

(non-engaged and time sensitive), and "efficient enthusiast" (engaged and time sensitive) for purposes of researching passenger experience[22]. Insights from such studies can inform and optimize the allocation of space for future airport terminal planning and design.

The length of passenger dwell time in departure lounges has economic implications as well. Studies have found that the amount of passenger dwell time strongly correlated with their likelihood of purchasing goods as well as the total amount of expenditure [23, 24]. One analysis of travelers in Spain's Asturias Airport found that "The purpose of the trip influences expenditure in the commercial area with vacationers spending more than business travellers. A clear relationship also exists between consumption in the commercial area of the airport and the length of stay prior to boarding. The level of consumption, however, is independent of the waiting time. If the boarding time is less than 45 min, business travellers tend to consume more than do vacation travellers"[24].

WHAT IF?

Around the end of the last century, **airports were often criticized as sterile, placeless, utilitarian spaces** - the quintessential "non-place"[25]. Recent designs have sought to **reconceive the airport as a destination** in its own right, a place to enjoy spending time (and by extension, money)[26]. In 2017, Pittsburgh International Airport became the first domestic airport to open to non-travelers[27]. This TSA-controlled policy has since expanded to other airports, including Tampa, Seattle-Tacoma, Detroit, New Orleans[28].

GOLDEN HOUR

Passengers are likely to feel anxious in an airport for several reasons, such as time pressure, security checks, the often long distances between passport control and the gates, and the generally non-familiar environment, which can be very disorienting. This travel related anxiety has been shown to increase constantly from the time they leave home until they pass through security. Once through security, stress decreases to near-baseline levels until the boarding process[29]. This intermediate phase of travel - where passengers are held in a confined area, but with relatively low levels of stress represents the **time when they are most likely to participate in impulse purchasing** opportunities - due to its common duration of roughly 60 minutes this period of time is referred to as the "**golden hour**" in airport retail circles[20].

Airports have sought to capitalize on the golden hour as much as possible, as the revenue generated during this timeframe represents a significant percentage of global airport revenue. In fiscal year 2017, non-aeronautical revenue accounted for 39.9% of global airport revenue, with retail concessions specifically accounting for 30.2% of total airport revenue[30]. In some cases non-aviation revenues account for over half of total airport revenues[15]. In fact, passenger retail revenue is essential to the financial stability of airports. In 2017 the total cost per passenger for airports was $13.69, while the aeronautical revenue generated per passenger was only $9.95.

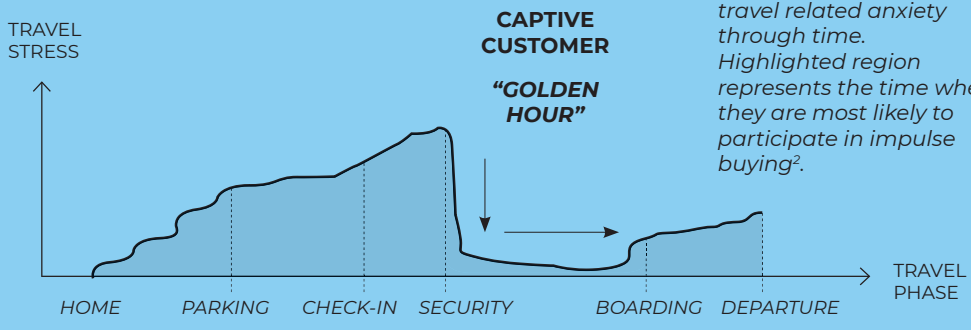


Figure 1. Passenger's travel related anxiety through time. Highlighted region represents the time when they are most likely to participate in impulse buying[2].

Travel Pillow

The travel pillow is a ubiquitous travel accessory, whose appeal may arise from providing more psychological, rather than physiological comfort.

DESIGN DECISIONS

The travel pillow is a ubiquitous travel accessory, with vast popularity but unproven utility in providing ergonomic support during sleep.

The design of the travel pillow may have its precursor in bathtub pillows. The idea for a portable U-shaped pillow that surrounds the neck was first patented in 1929, to be used to support a reclining person in the bathtub[1]. In the patent filing, the bathtub pillow's crescent shape is described to be "such that the head (is) most comfortably supported, and yet the wearer will not feel confined or oppressed"[2]. Today, the travel pillow has become a universal modern day travel accessory for both air and train travel, rising in popularity in the last four decades and becoming ubiquitous in the last two decades[1].

The human head weighs approximately 10 pounds, a significant load. **Most U-shaped pillows might not be built firm enough or high enough to help most people**, to effectively keep their neck in a comfortable physiological position while asleep[3]. In addition, it provides little side support to prevent lateral movement, and almost no support in the front when the chin tilts forward. To address this, **recent attempts to improve the travel pillow have included straps to hold one's head in place[4]**, or box-line contraptions to place one's head in [5,6]. In addition, different manufacturers have been experimenting with different types of microbeads to help shut out more sound to the user.

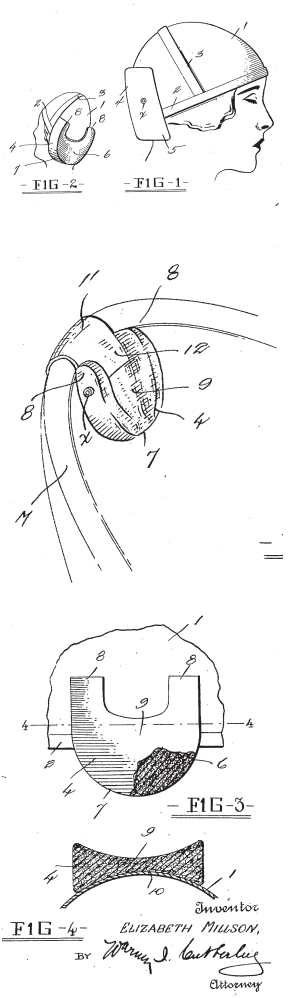


Figure 1: US Patent for a bath pillow: US1713049A, issued 1929 to Elizabeth Millson[2]

Figure 2. Clöudz EZ-Inflate travel pillow can be inflated with three or four breaths and rested on a tray table or lap[6].

Figure 3. Relax Alley Travel Restband[6].

Figure 4. Woollip travel pillow can be used against the wall of the plane or the tray table[6].

Figure 5. Ostrich Pillow can be used both on the plane and in the airport, and is filled with silicon covered micro-beads for sound reduction[6].

EFFECTS ON PASSENGERS

Popular opinion is split on their utility, and little academic research has been conducted on how much support the neck needs while sleeping, and whether travel pillows help, hurt, or have no effect on the passenger[1]. Yet, their neverending popularity remains a curious phenomenon.

Els van der Helm, a sleep expert with a background in neuroscience and psychology, hypothesizes that the travel pillow "preys on our fear that everyone else is sleeping around you, and you won't be able to sleep. You have this desperate feeling, so you throw money at the problem"[1]. It is possible that the popularity of travel pillows may be due to herd mentality or the power of the placebo effect. It is also possible that travel pillows are being used as a tactic to avoid accidentally leaning on a stranger while sleeping, a major intrusion of fellow passengers' personal space and a potential source of embarrassment.

In addition, **travel pillows' appeal may lay in its cocoon-like association**, especially with newer designs that encompass the whole head such as the Ostrichpillow[7]. People often have a strong desire to shut out the sensory bombardment of the outside world during sleep, and this usually manifests by people curling up under blankets, or seeking a dark, safe space to take a nap. This desire is a theme frequently explored in the art and design world, and many artists have created physical cocoons for sensory respite, or even pillows to silently scream into in public spaces[8].

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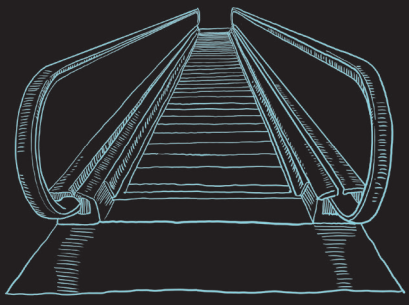

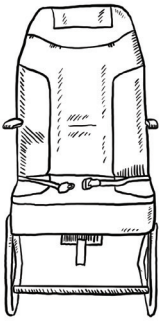

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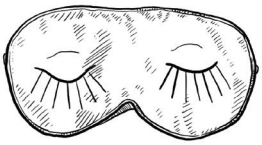

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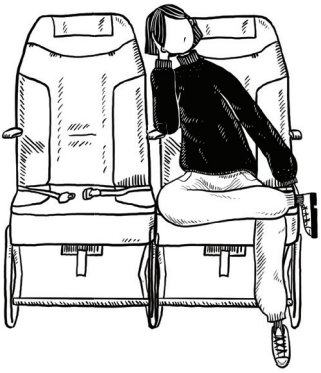

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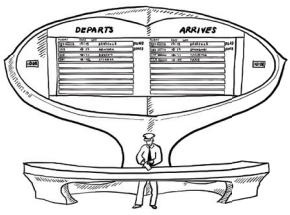

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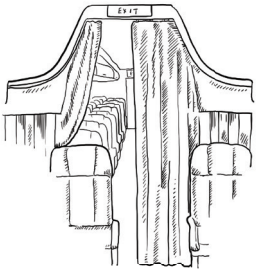

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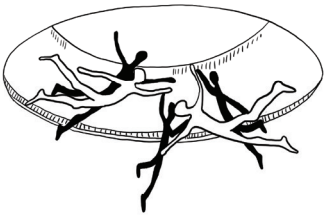

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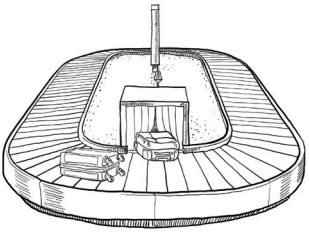

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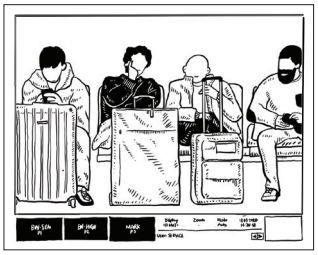

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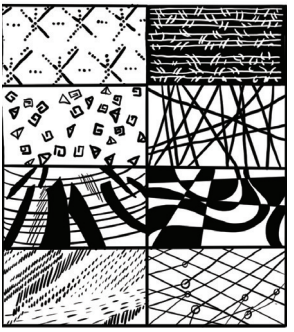

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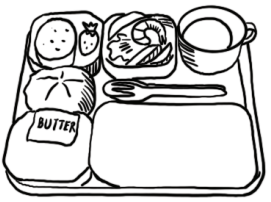

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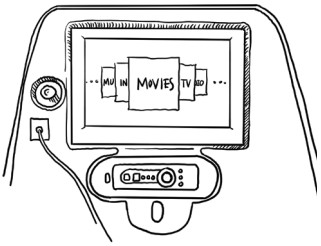

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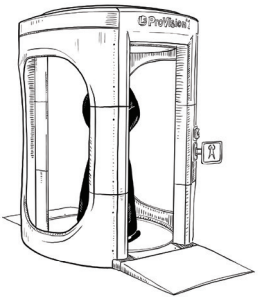

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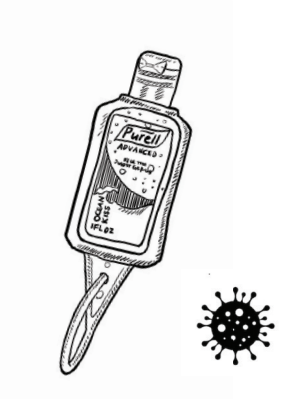

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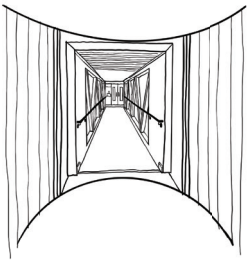

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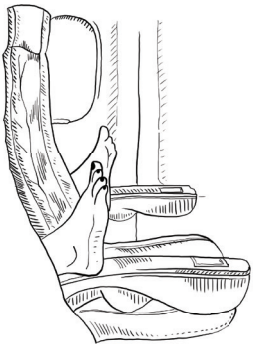

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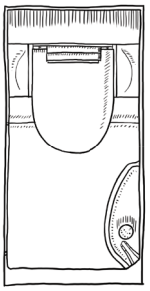

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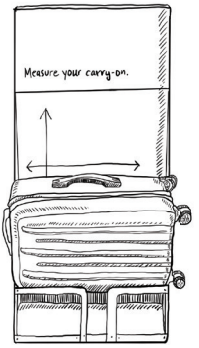

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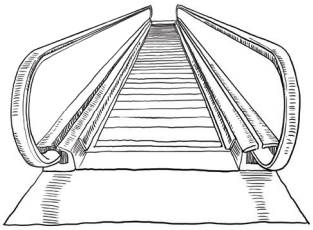

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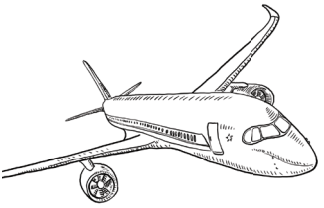

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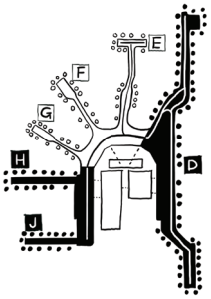

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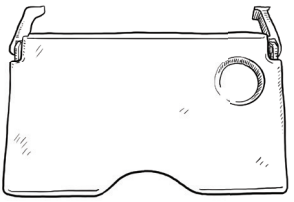

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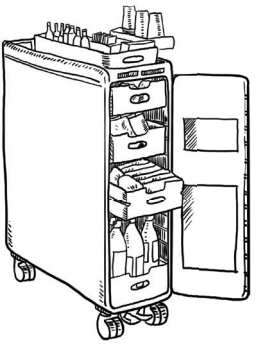

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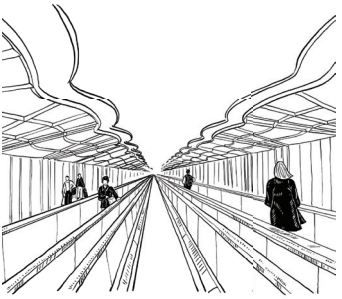

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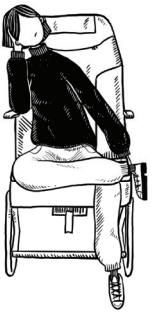

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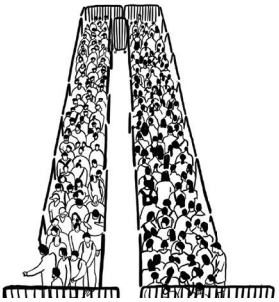

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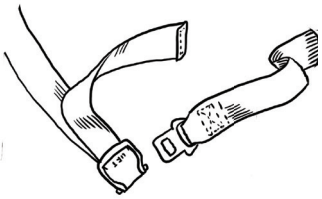

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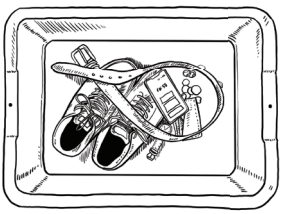

SAFETY

SAFETY CARD

SPACE

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TRAVEL PILLOW

WORKS CITED

A

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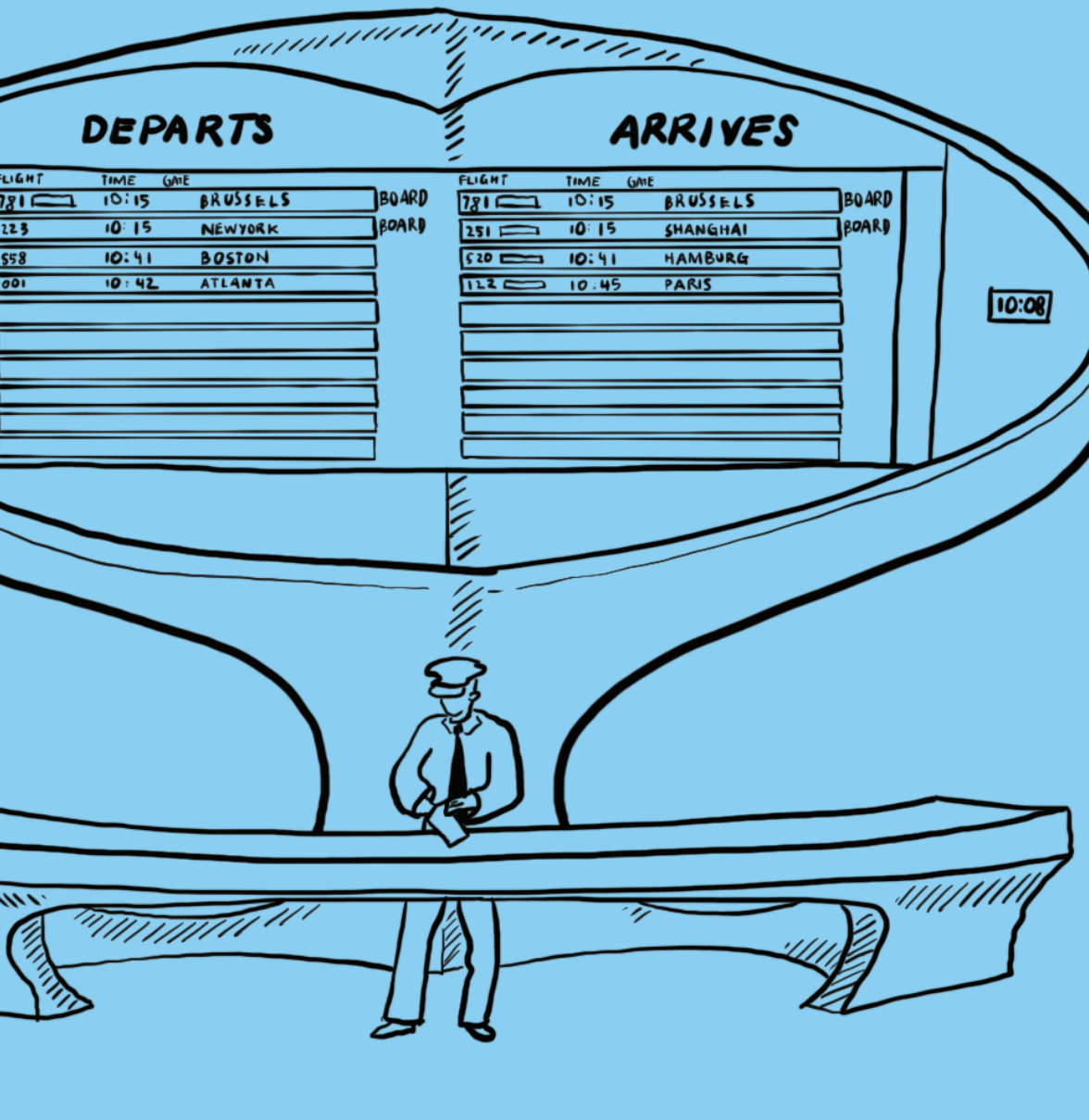
10:08


DEPARTS
ARRIVES
FLIGHT TIME GATE
781 10:15 BRUSSELS BOARD
223 10:15 NEWYORK BOARD
558 10:41 BOSTON
001 10:42 ATLANTA
FLIGHT TIME GATE
781 10:15 BRUSSELS BOARD
251 10:15 SHANGHAI BOARD
520 10:41 HAMBURG
122 10:45 PARIS
10:08